IIW Guideline for
International Welding Engineers, Technologists,
Specialists and Practitioners

PERSONNEL WITH QUALIFICATION FOR WELDING COORDINATION

Minimum Requirements for the Education, Examination and Qualification

IAB-252r5-19

MINIMUM REQUIREMENTS FOR THE EDUCATION, TRAINING, EXAMINATION, AND QUALIFICATION

PERSONNEL WITH QUALIFICATION FOR WELDING COORDINATION

(as described in ISO 14731 and other International and National Standards)

International Welding Engineer (IWE)
former : Doc. IAB-002-2000/EWF-409 Rev. 2

International Welding Technologist (IWT)
former : Doc. IAB-003-2000/EWF-410 Rev. 2

International Welding Specialist (IWS)
former : Doc. IAB-004-2000/EWF-411 Rev. 1

International Welding Practitioner (IWP)
former : Doc. IAB-005-2002/EWF-451 Rev. 1

Prepared and issued by the IAB-International Authorisation Board based on the EWF above mentioned Guidelines
Under the authority of the IIW-International Institute of Welding

For more information regarding the Qualifications System, the IAB/EWF Management Team or the National ANB should be contacted
(see in the IIW and EWF sites the ANB contacts)

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Preface

This document is based upon the European Welding Engineer/ Technologist/ Specialist/ Practitioner Guidelines as developed by the European Federation for Welding, Joining and Cutting (EWF), through an Agreement first signed 19 July, 1997, at the Annual Meeting of the International Institute of Welding (IIW) in San Francisco, California, USA and which has been renewed and further developed since then. It has been established in that Agreement that the International Welding Engineer/ Technologist/ Specialist/ Practitioner Diploma is equivalent to the European Welding Engineer/ Technologist/ Specialist/ Practitioner Diploma.

The International Institute of Welding IIW has delegated the responsibility for the management of the qualification and certification systems to the International Authorisation Board (IAB).

This guideline for the international education, training, examination and qualification of welding personnel has been prepared, evaluated and formulated by Group A "Education, Training and Qualification" of the IAB.

Any EWF Authorised National Body ANB is permitted to issue EWF diplomas equivalent to IIW ones that have been issued by the same ANB (Automatic Route).

Copies of this document are available from the EWF/IAB Secretariat or the national ANB's.

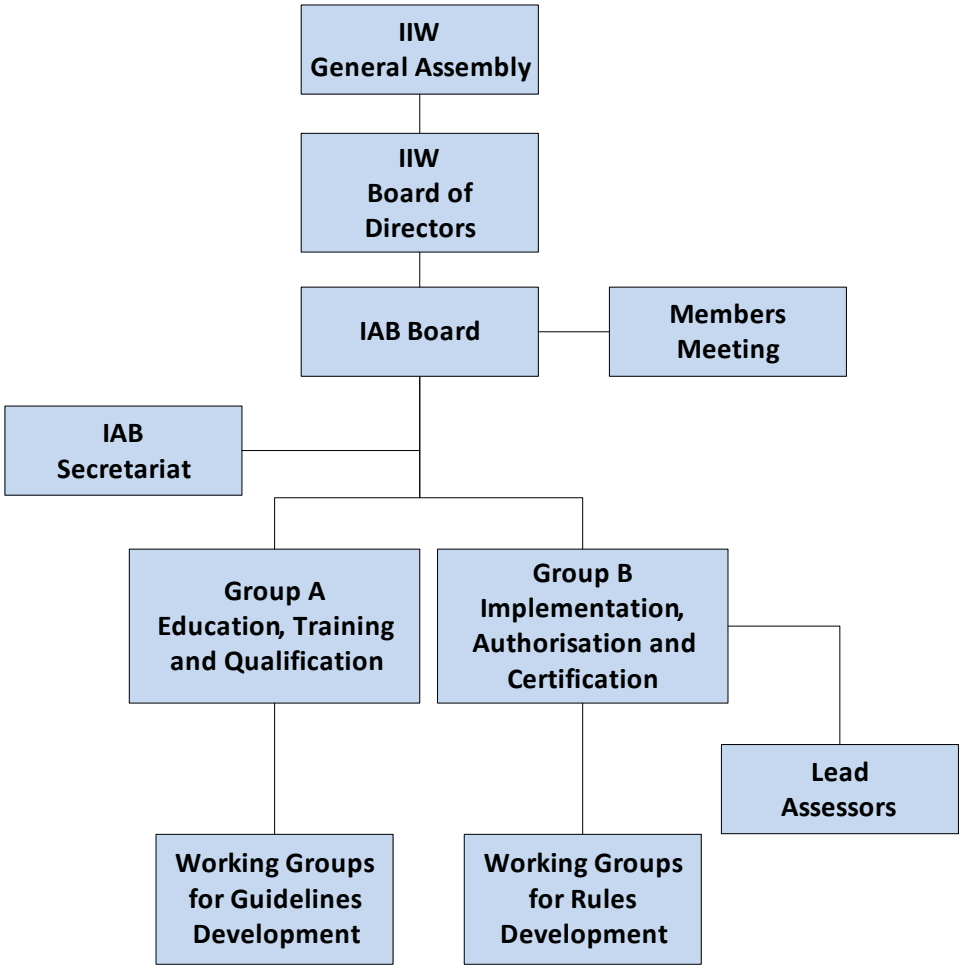

Figure 1: Organisation of the IAB

MINIMUM REQUIREMENTS FOR THE EDUCATION, TRAINING, EXAMINATION AND QUALIFICATION OF PERSONNEL

1 Introduction

Section I of the guideline covers the minimum requirements for education and training, which have been agreed upon by all IAB - ANBs, in terms of objectives, scope, Learning Outcomes and the teaching hours to be devoted to achieving them. It will be revised periodically by IAB Group A to take into account changes to reflect the "state of the art". Students successfully completing a course of education and examinations will be expected to be capable of applying the welding technology at a level consistent with the qualification diploma.

Section II of the guideline covers the rules for examination and qualification.

The modular course contents are given in the following structure (overview):

Modules of theoretical education and fundamental practical skills	Teaching hours*							
	IWE		**IWT**		**IWS**		**IWP**	
	MT	**P1**	**MT**	**P1**	**MT**	**P1**	**MT**	**P1**
1. Welding processes and equipment	95	46	86	46	53	20	32	19
2. Materials and their behaviour during welding	115	33	96	31	56	16	23	10
3. Construction and design	62	14	44	14	24	4	6	0
4. Fabrication, applications engineering	116	0	83	0	56	0	29	0
Sub-total	**388**	**93**	**309**	**91**	**189**	**40**	**90**	**29**
Fundamental practical skills (Part 2)	60		60		60		60	
Total	**448**		**369**		**249**		**150**	

* Teaching hours are the minimum for the Standard Route, see 2.6;
MT = Module Total (Part 1 + Part 3);
P1 = Part 1;
Figures under P1 are given for the Standard Route (see 4.1).

It is to be noted that the overall structure of the syllabus for all levels (IWE, IWT, IWS, and IWP) is similar, but some topics are not considered in all levels of qualification. These topics are indicated by 0 hours in this guideline. The depth to which a 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.

The objectives of the education, training and examinations in terms of learning outcomes are described in two ways: generically for each level as mentioned in Appendix V; and more specifically and in more detail under the heading of 'Expected Results' in each section of the Syllabus.
Additionally, Appendix V shows a classification for each level of learning outcome (general) into an EQF-level (EQF= European Qualification Framework).

The text on the following page is the IIW view of the relevant **Task Descriptions** and should be considered only as guidance to explain the level of knowledge, competence and skills, for each qualification level under this guideline.

Task Descriptions: Knowledge, skills and competence levels achieved for each qualification level and their correlation with ISO 14731

IWE – Knowledge, Competence and Management
A candidate completing the IWE training under this program is expected to acquire advanced knowledge and critical understanding of welding technology application.
He / she shall have advanced competence and skills at a level that is required in the field of welding technology which demonstrate:

- technology mastery and required innovation
- being able to solve high-level complex and unpredictable problems
- the ability to manage high complex technical and professional activities or projects related to welding applications
- taking responsibility for decision making in unpredictable work or study context
- taking responsibility for managing professional development of individuals and groups

IWT – Knowledge, Competence and Management
A candidate completing the IWT training under this program is expected to acquire an overall knowledge and understanding of welding technology application.
He / she shall have competence and skills at a level that is required in the field of welding technology which demonstrate:

- being able to solve low-level complex problems
- the ability to manage in detail the welding applications and related professional activities or projects
- taking responsibility for decision making in low-level complex work or study context
- taking responsibility to define the tasks of welding or related personnel
- being able to manage professional development of individuals and groups

IWS – Knowledge, Competence and Management
A candidate completing the IWS training under this program is expected to acquire a specialized and factual knowledge in the field of welding technology.
He / she shall have competence and skills at a level that is required in the field of welding technology which demonstrate:

- being able to develop solutions on common/regular problems
- being able to manage and supervise common or standard welding applications and related professional activities
- taking responsibility for decision making in common or standard work
- taking responsibility to supervise the tasks of welding and related personnel.

IWP – Knowledge, Competence and Management
A candidate completing the IWP training under this program is expected to acquire a basic knowledge in the field of welding technology.
He / she shall have competence and skills at a level that is required in the field of welding technology which demonstrate:

- being able to develop solutions on basic and specific problems
- being able to supervise basic welding applications and related professional activities
- taking responsibility for decision making in basic work
- taking responsibility to supervise the tasks of welding and related personnel

In correlation with essential coordination tasks as detailed in EN ISO 14731, the previous mentioned competences and skills will enable the candidate to effectively perform the following tasks:

Type of Construction concerned	IWE	IWT	IWS	IWP
	Any type	With a low level of complexity	Regular and common	Basic specific works
Welding construction contract requirements	able to review			not able to perform
Technical review of the welding construction	able to perform the task			not able to perform
Subcontracting activities	able to specify requirements and assessment protocol, to supervise implementation and monitor			able to supervise implementation and monitor
Welding personnel and related personnel needs and competences/ skills;	able to specify, supervise and manage			able to supervise the welding personnel and monitor
Equipment and means needed for the construction;	able to specify, validate and manage the equipment, including the calibration if needed			able to understand and supervise the proper use
Manufacturing plan;	able to specify, develop, validate and manage			able to monitor and implement
Welding procedures needed for the construction;	able to specify, develop, evaluate, validate and manage			able to understand, implement
Working instructions;	able to specify, develop, evaluate and manage			able to understand, implement
Base materials and welding consumables;	able to specify, validate and manage			able to monitor and supervise the proper use
Inspection Testing Plan;	able to specify, review, develop, evaluate, validate and manage			able to understand, implement and monitor
Heat treatments;	able to specify, develop, evaluate, validate and manage			able to understand, implement, supervise and monitor
Corrective actions to solve welded construction non-conformances;	able to specify, review, develop, evaluate, validate and manage			able to implement, monitor and control
Identification and traceability used in welding manufacturing;	able to specify, develop, evaluate, validate and manage processes			able to understand, control and supervise
Construction quality records.	able to specify, develop, evaluate, validate and manage processes related to monitor and control			able to collect, control, perform and supervise

Characterization of the general description of IIW Qualifications, describing the Qualification descriptors in terms of Knowledge – K, Skills – S, Competences - C for each IIW welding coordination qualification

SUMMARY DESCRIPTION							
QUALIFICATION	**KNOWLEDGE APPLICATION**	**SKILLS APPLICATION**	**COMPETENCES**	**EQF LEVEL**	**TEACHING HOURS**	**WORKLOAD* (hours)**	**ECVET POINTS****
INTERNATIONAL WELDING ENGINEER	Highly specialised and forefront knowledge including original thinking, research and critical assessment of theory, principles and applicability of welding related technologies.	Highly specialised problem- solving skills including critical and original evaluation, allowing to define or develop the best technical and economical solutions, when applying welding processes and related technologies, in complex and unpredictable conditions.	Manage and transform the welding processes and related technologies in a highly complex context. Act as the full responsible person for the definition and revision of the welding and related personnel's tasks.	7	448	836	75
INTERNATIONAL WELDING TECHNOLOGIST	Advanced knowledge and critical understanding of the theory, principles and applicability of welding and related technologies.	Advanced problem-solving skills including critical evaluation, allowing to choose the proper technical and economical solutions, when applying welding and related technologies, in complex and unpredictable conditions.	Manage the applications of welding and related technologies in a highly complex context. Act autonomously as the responsible person for the decision making and the definition of the welding and related personnel's tasks.	6	309	534	50
INTERNATIONAL WELDING SPECIALIST	Specialised, factual and theoretical knowledge of the theory, principles and applicability of the welding and related technologies.	Specialised range of cognitive and practical skills, allowing to develop solutions or choose the appropriate methods, when applying welding and related technologies, in common/regular problems.	Manage and supervise common or standard welding applications and related technologies, in an unpredictable context. Take responsibility with limited autonomy for decision making in common or standard work and supervise the welding and related personnel's tasks.	5	189	312	30
INTERNATIONAL WELDING PRACTITIONER	Factual and theoretical knowledge (basic understanding) of the theory, principles and applicability of the welding and related technologies.	Fundamental range of cognitive and practical skills required to identify proper solutions, when applying welding and related technologies, in basic and specific problems.	Self-manage within the guidelines of work, the applications of welding and related technologies, in a predictable context, but subject to change. Take responsibility without autonomy for decision making in basic work and supervise basic tasks of welding and related personnel.	4	150	247	8

* Workload is the minimum duration of the Teaching hours for the Standard route plus the hours the student needs for self-study.
** ECVET is the European Credit system for Vocational Education and Training.

2 Routes to Qualification

Five distinct routes to gaining the qualifications described in this document have been agreed.

1. The Standard Route
2. The Alternative Route
3. Blended Learning Route
4. The Experiential Route
5. Transition Route

2.1 The Standard Route

The Standard Route requires successful completion of IAB approved courses which are designed to meet all the requirements in this Guideline. This is the route (Path 1 in diagrams 1, 2, 3, and 4) recommended by IAB as offering the fastest, most comprehensive manner in which the syllabus may be covered.

The Standard Route also allows a limited amount of prior learning (Part 1 of each qualification course, see Section I) to be taken into account, for example during University or College courses or by blended learning (Path 2 in diagrams 1, 2, 3, and 4). This prior learning shall be approved by the ANB.

2.2 The Alternative Route

The Alternative Route is aimed at individuals who may already have experience of the job function at a particular level without holding the appropriate qualification diploma. These individuals will have already gained full or part knowledge of the syllabus defined in this guideline and can demonstrate their capability to proceed to examination either directly without compulsory attendance at an ANB approved training course or by attending only part of such a course.

2.3 Blended Learning Route

The Part 1 theory module may be taught in Blended Learning Programs under control of the ANB.

When the Part 1 and Part 3 theory modules are combined or the Part 3 theory module is taught separately the requirements of the latest edition of the Blended Learning Guideline IAB 195 shall be followed.

2.4 The experiential Route or “The Career Development Route”

The Experiential Route allows considering whether professional experiential learning can be recognised for career progression either from IWP diploma holders to IWS or IWS diploma holders to IWT courses who do not satisfy the relevant general access conditions. By this route, it is possible to run a career path from the welder through the IWP and IWS up to the IWT, more detailed information is given on items 3.2 and 3.3.

2.5 The Transition Route

The Transition Route is described in Section II, item 10.

2.6 Teaching hours

The meaning of the teaching hours is the following:

Standard Route:	minimum number of hours devoted to the subject
Alternative Route:	recommended number of hours devoted to the subject
Distance Learning:	recommended number of hours devoted to the subject
Part 1 (P1):	maximum number of hours devoted to the subject in Part 1
Part 3 (P3):	minimum or recommended number of hours devoted to the subject in Part 3

A "teaching hour" shall contain at least 50 minutes of direct teaching time.

3 General Access Conditions

In a separate document (Directory of Access Conditions, Doc. IAB-020-see latest edition) the defined access conditions approved by Group B "Implementation and Authorisation" of the IAB are given in detail for all countries participating in the IAB system. Applicants not fulfilling the access conditions may follow the course as guests, but entry to the related examination is not permitted.

The following general conditions shall be applied to all courses:

1. Students who have successfully passed the intermediate examination (Part 1) of the course are allowed to attend Part 2 and Part 3 of the course;

2. The implementation of the access conditions is the responsibility of the ANB.

In following parts of chapter 3 and in Special Requirements in chapter 4 of the guideline, diagrams are used for schematic illustration of the text. It should be noted that it is the text which is binding

3.1 International Welding Engineer IWE

It is agreed that entry to the program should be on a postgraduate level. Participants should have a primary degree in an engineering discipline or its equivalent recognised by the national government and assessed by the ANB. Therefore, it would be expected that participants should have at least a Bachelor degree at university level with a minimum study of 3 years, e.g.:

- a relevant qualification from an accredited program in accordance with the Washington Accord for professional qualification of engineers, or
- a First Cycle Bologna Framework engineering qualification, or
- an engineering qualification at EQF Level 6,
- or equivalent.

In case of co-operation arrangements, e.g. with universities, according to which the IWE Part 1 (IWE 1) of the syllabus with scope, objectives, and learning outcomes (see Section I) is presented under careful control of the ANB, the participant is allowed to enter the IWE course through the Path 2 (see item 2.1 and the diagram 1 below).

The following additional conditions shall be observed for the different routes through the IWE course:

1. Students who have authenticated evidence that they have passed the examinations in all subjects of their Bachelor engineering degree studies but still have to complete a thesis are allowed to attend Part 2 (IWE 2) and Part 3 (IWE 3) of the IWE course and the corresponding written parts of the final examination;

2. Students shall present their degree diploma to the Board of Examiners before being allowed to take the final oral examination for IWE.

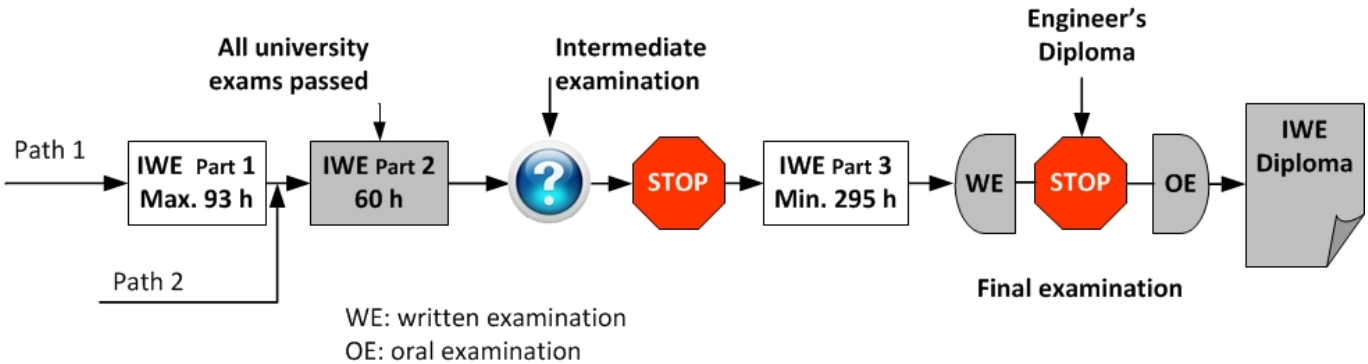

Diagram 1: IWE-route

3.2 International Welding Technologist IWT

It is agreed that entry to the program via Path 1 and 2 should be on the basis of a higher technical education below that required for the International Welding Engineer. Participants should have a primary degree in an engineering discipline, e.g.:

- a relevant qualification from an accredited program in accordance with the Sydney Accord for professional qualification of engineering technologists, or
- a Short Cycle Bologna Framework engineering qualification, or
- an engineering qualification at EQF Level 5,
- or equivalent.

In case of co-operation arrangements, e.g. with technical colleges, according to which the IWT Part 1 of the curriculum structure (see Section I) is presented under careful control of the ANB, the participant is allowed to enter the IWT course through Path 2 (see item 2.1 and the diagram 2 below).

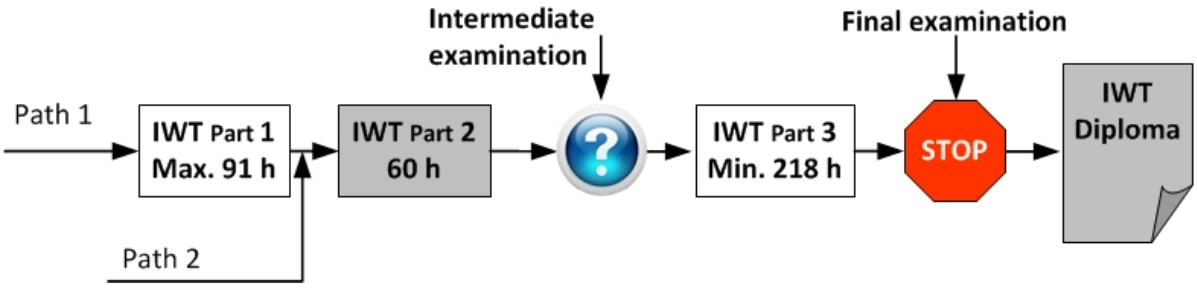

Diagram 2: IWT-Route

Applicants who have gained relevant industrial experience may take the Experiential Route to meet the General Access Conditions for IWT:

1. CIWS with a minimum of two years' experience, post certification, as responsible for welding coordination for a welded product manufacturer working in full compliance with the Standard Quality Requirements of ISO 3834-3 or above
   or

2. Six years of experience working at Technologist level, after gaining the IWS diploma and within the preceding eight years.

All Experiential Route applicants will be required to attend the IWT Part 3 taught course and pass all Technologist level examinations to gain the IWT diploma

3.3 International Welding Specialist IWS

It is agreed that entry to the program through Path 1 and 2 should be on the basis of a specific technical education below that required for the International Welding Technologist but higher than a professional worker, e.g. a relevant qualification from an accredited program:

- in accordance with the Dublin Accord for the professional qualification of engineering technicians, or
- an engineering qualification at EQF Level 4,
- or equivalent.

In case of co-operation arrangements, e.g. with technical colleges, according to which the IWS Part 1 of the curriculum structure (see Section I) is presented under careful control of the ANB, the participant is allowed to enter the IWS course through Path 2 (see item 2.1 and the diagram 3 below).

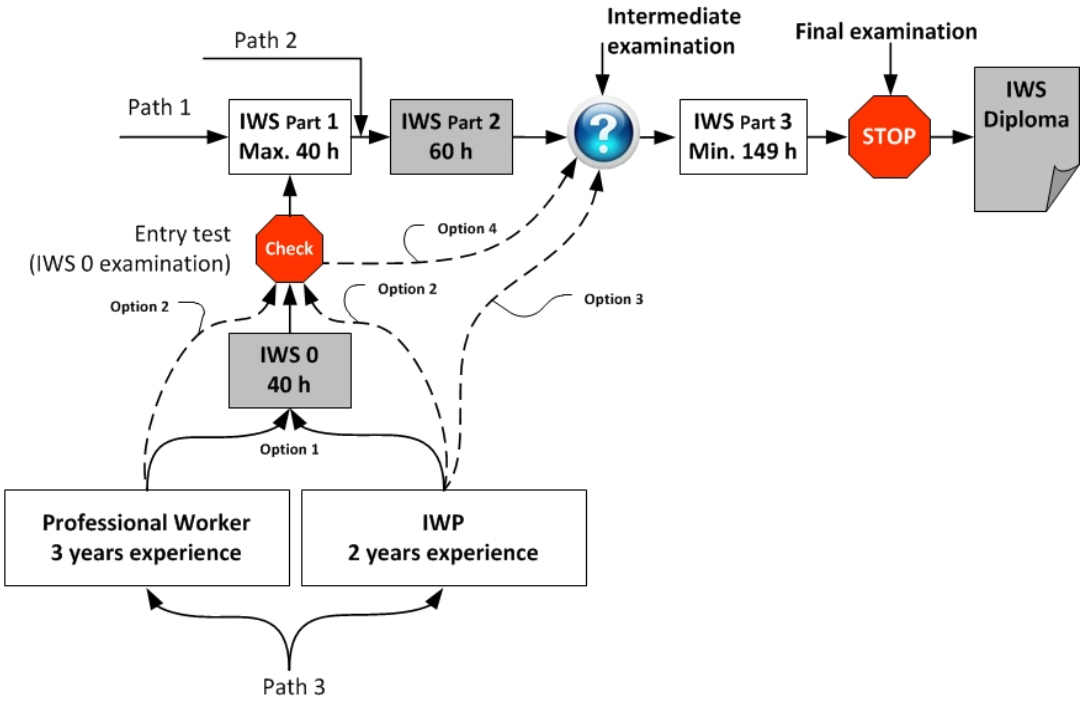

Diagram 3: IWS-Route

The following additional conditions shall be observed for the different routes through the IWS course:

1. Path 1 and 2: a minimum of 2 years' job related experience is required;

2. Path 3: For the access to the module IWS Part 0 the minimum requirements are:

   - International Welding Practitioner (IWP) and minimum 2 years' experience (see on above diagram option 1) OR
   - Qualification of a professional worker (with diploma after examination) in metalworking professions at EQF Level 3, or equivalent and minimum 3 years' experience in welding related activities,
   - The education National definitions for a professional worker are given in the Directory of Access Conditions (see on above diagram 3, option 1).

3a. A qualified professional worker (as stated above) not fulfilling the IWS National Access Requirements should be allowed to go directly to the IWS Part 0 examination if they can prove that they have achieved the knowledge prescribed by the IWS Part 0 (see on above diagram 3, option 2).

3b. An IWP Diploma holder not fulfilling the IWS National Access Requirements should be allowed to go directly to the IWS Part 0 examination if they can prove that they have achieved the knowledge prescribed by the IWS Part 0 (see on above diagram option 2), if the applicant has success on this exam, he/she may skip the IWS Part 1 and only perform the IWS Part 1 intermediate exam. At the discretion of the ANB a partial or full exemption from Part 2 may be granted. (see diagram 3, option 2 and 4)

4. If the IWP Diploma holder fulfils the IWS National Access Requirements, he may skip the entry test (IWS Part 0 examination) and IWS Part 1 and only perform the IWS Part 1 intermediate exam (see on above diagram 3 option 3). At the discretion of the ANB a partial or full exemption from Part 2 may be granted.

3.4 International Welding Practitioner IWP

In order to enter the International Welding Practitioner course, participants are required to be skilled in practical welding and to have had experience as a welder in industry.
The course is intended to build theoretical knowledge and practical welding skills.

In case of co-operation arrangements, e.g. with technical colleges, according to which the IWP Part 1 of the curriculum structure (see Section I) is presented under careful control of the ANB, the participant is allowed to enter the IWP course through the Route 2 (see item 2.1 and the diagram 4 below).

The following standard access conditions are applicable to the IWP course. Applicants are required to

1. Hold a valid pipe welder qualification certificate in accordance with ISO 9606-1/-2 H-L045 ss nb or J-LO45 ss nb or the combination PC and PH ss nb in the same material group;

Or

2. Hold a valid plate welder qualification certificate in accordance with ISO 9606-1 for the conditions PE ss nb or PC and PF ss nb, or in accordance with ISO 9606-2 for the conditions PE bs or PC and PF bs;

Or

3. Hold an alternative national welder qualification with the same range of qualification as that in 1 or 2 above;

And

4. Have, a recommended minimum of, 2 years job-related experience as plate or pipe welder.

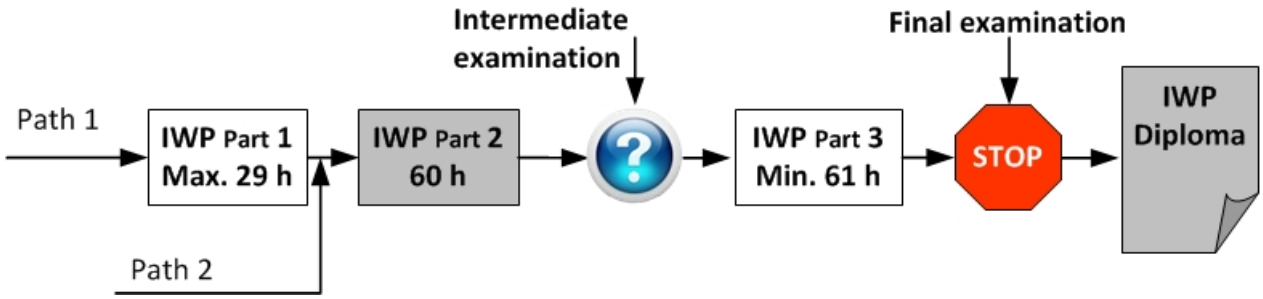

Diagram 4: IWP-Route

4 Special Requirements

4.1 Standard Route

Applicants (excluding guests) shall satisfy the ANB access conditions. If the ANB decides that the access conditions are adequately met, the applicants are then required to attend a training course conducted by an Approved Training Body (ATB) giving as a minimum the hours of instruction detailed in this Guideline as teaching hours. There will be written and oral examinations (where applicable) for the award of the applicable IIW Diploma.

The maximum number of hours of the lectures, which can be included in Part 1 are given in the table included in Chapter 1 above. The definition of the elements of the syllabus which are included in Part 1 is the responsibility of the ANB.

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, with the exception that **training must conclude with Module 4 "Fabrication, applications engineering" in Part 3.**

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.

The objectives of the education, training and examinations in terms of learning outcomes are described in two ways: generically for each level (see Introduction); and more specifically and in more detail under the heading of 'Expected Result' in each section of the Syllabus.

The rules for the conduct of the final examination by the ANB are prescribed under Examination and Qualification in this guideline (Section II).

4.2 Alternative Route

Applicants shall submit an application form to the ANB together with the appropriate documents indicated in the sub clauses 4.2.1, 4.2.2, 4.2.3 or 4.2.4 for a paper assessment.

The ANB shall check the documentation submitted to ensure the applicant meets the national Access Conditions (see doc IAB-020- latest edition). In addition, the ANB check should evaluate and verify the applicant's experience, training, education and practice of the job function in welding at the relevant qualification level. The result of this assessment shall determine if the applicant is suitable for further detailed assessment (Appendix III).

4.2.1 International Welding Engineer IWE

The applicant shall submit:

- An application form
- A copy of a diploma showing graduation in an engineering subject complying with the Access Conditions.
- A curriculum vitae (CV) - resume containing professional information:
  - evidence of at least 4 years' job function in welding at the level of an engineer (in a period of 6 years before application);
  - justification of candidate's experience, training, and education to become IWE (may include other test results).

Applicants who satisfy the Access Conditions AND already hold an IWT diploma should be considered under the Alternative Route

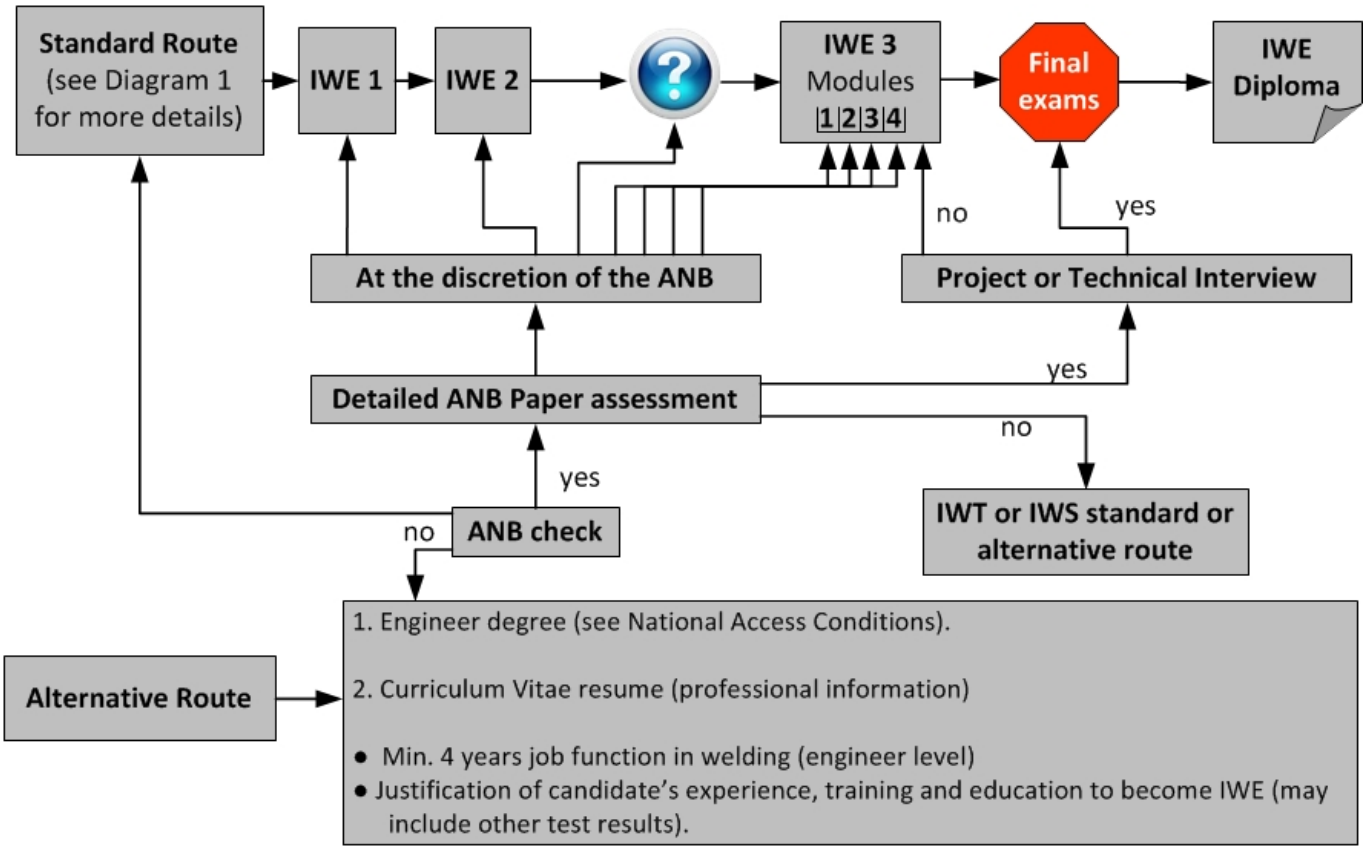

Diagram 5: Alternative versus Standard Routes for IWE qualification
(see also Appendix III: Requirements for ANB Detailed Assessment)

4.2.2 International Welding Technologist IWT

The applicant shall submit:

- An application form
- A copy of a diploma showing graduation as technologist complying with the Access Conditions.
- A curriculum vitae (CV) - resume containing professional information:
  - evidence of at least 4 years' job function in welding at the level of a technologist (in a period of 6 years before application);
  - justification of candidate's experience, training, and education to become IWT (may include other test results).

Applicants who satisfy the Access Conditions AND already hold an IWS diploma should be considered under the Alternative Route.

Applicants who satisfy the Access Conditions AND hold an IWI-C diploma should be considered under the Alternative Route.

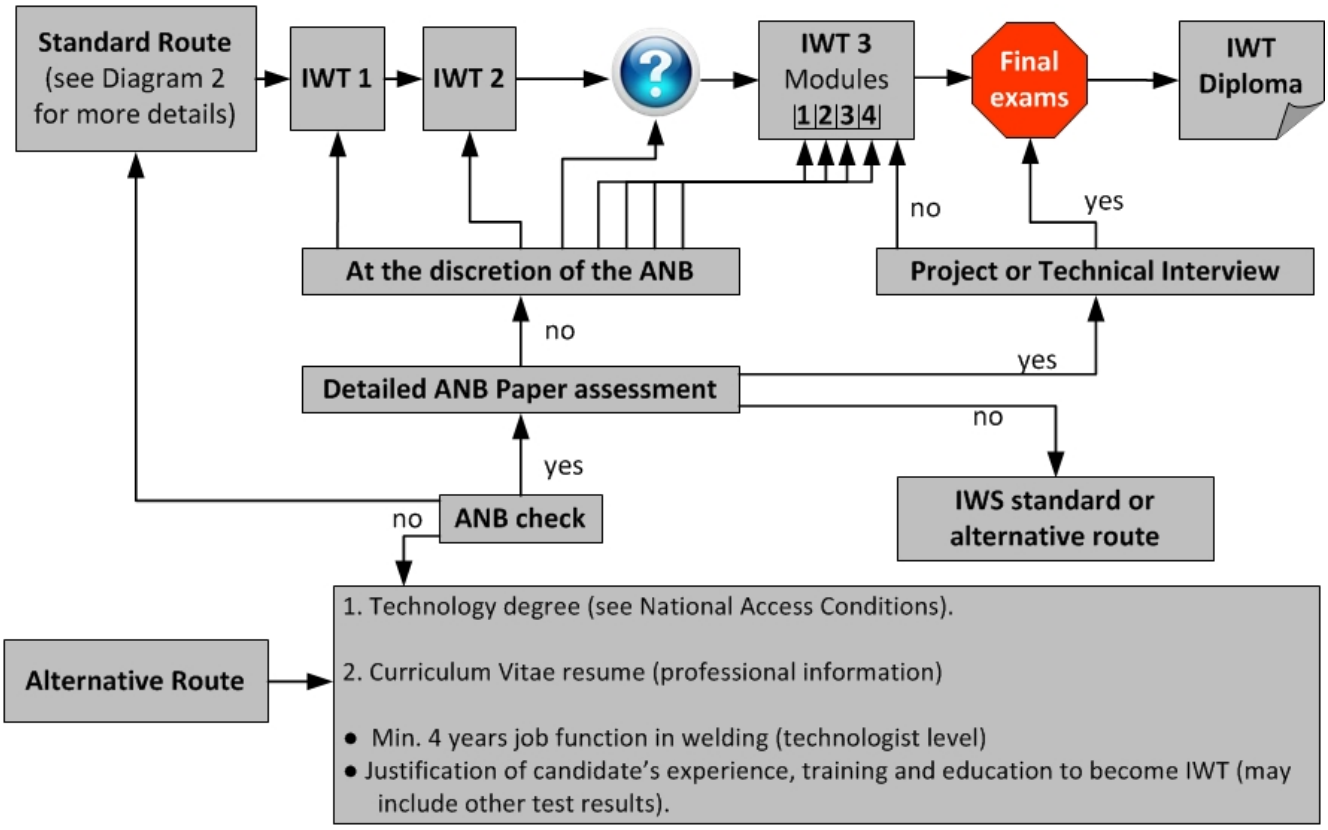

Diagram 6: Alternative versus Standard Routes for IWT qualification
(see also Appendix III: Requirements for ANB Detailed Assessment)

4.2.3 International Welding Specialist IWS

The applicant shall submit:

- An application form
- A copy of documentary proof showing compliance with the Access Conditions for IWS.
- A curriculum vitae (CV) - resume containing professional information:
  - evidence of at least 3 years' job function in welding at a level equivalent to that of a specialist (in a period of 6 years before application);
  - justification of candidate's experience, training, and education to become IWS (may include other test results).

Applicants who satisfy the Access Conditions AND hold an IWI-S diploma should be considered under the Alternative Route.

Applicants who do not satisfy the Access Conditions but who have a minimum of six years of experience in welding coordination and demonstrate to the ANB that their combination of education, training and experience in welding technology has provided a level of knowledge equivalent to the current IIW requirements should be considered under the Alternative Route.

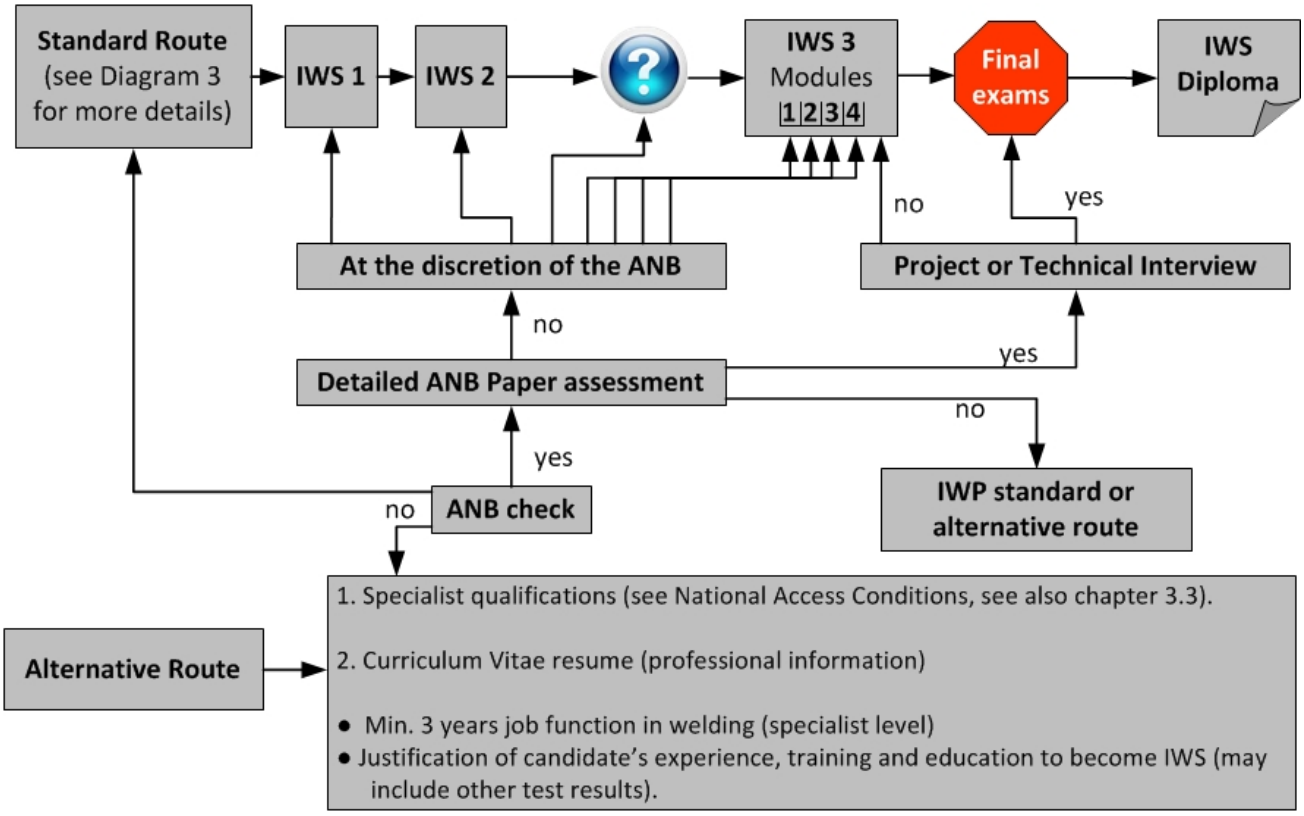

Diagram 7: Alternative versus Standard Routes for IWS qualification
(see also Appendix III: Requirements for ANB Detailed Assessment)

4.2.4 International Welding Practitioner IWP

The applicant shall submit

- An application form
- A copy of a valid welder qualification certificate according with chapter 3.4 of the standard route.
- A curriculum vitae (CV) - resume containing professional information:
  - min. 3 years' job function in welding as a certified plate or tube welder in a period of 5 years before application plus
  - min. 1 year job function in welding practitioner level in a period of 3 years before application;
  - justification of candidate's experience, training, and education to become IWP (may include other test results).

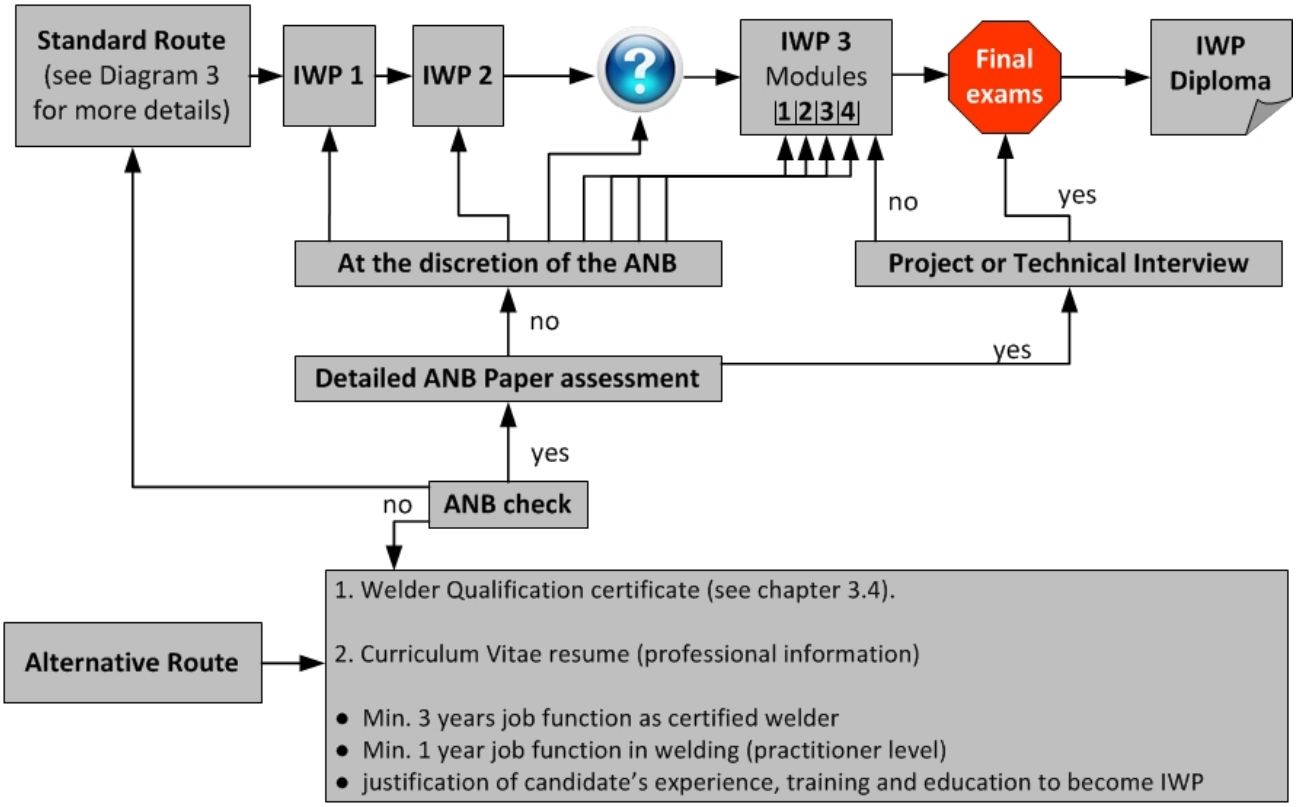

Diagram 8: Alternative versus Standard Routes for IWP qualification
(see also Appendix III: Requirements for ANB Detailed Assessment)

Section I: Theoretical and Practical Education – Part 1, Part 2 and Part 3, Syllabus and Performance Objectives

On the following pages it is presented the training syllabus for each module, each module syllabus of the training

Figures are teaching hours. Those after "P1=" are maximum teaching hours which can be included in Part 1

I.1. Theoretical Education - Part 1 and Part 3

Module 1: Welding processes and equipment

Characterization of the general description of Module 1 – Welding Processes and Equipment, describing the Qualification descriptors in terms of Knowledge – K, Skills – S, Competences - C for each IIW welding coordination qualification

COMPETENCE UNIT 1: WELDING PROCESSES AND EQUIPMENT							
QUALIFICATION	**KNOWLEDGE**	**SKILLS**	**COMPETENCES**	**EQF LEVEL (EQF L)**	**TEACHING HOURS**	**WORKLOAD (WL)**	**ECVET POINTS**
INTERNATIONAL WELDING ENGINEER	Highly specialized knowledge (able to deduce, detail and explain) and critical assessment of the principles of welding and cutting processes and applications, either manual or mechanized or automatic or robotized.	Highly specialised problem-solving skills including critical and original evaluation, allowing to define or develop the best technical and economical solutions when applying welding processes and related technologies, in complex and unpredictable conditions.	Manage in detail the welding processes and cutting applications in a highly complex context. Act as the responsible person for the definition of the welding personnel tasks.	6	155	250	20
INERNATIONAL WELDING TECHNOLOGIST	Advanced knowledge (able to deduce, detail and explain) and critical assessment of the principles of welding and cutting processes and applications, either manual or mechanized or automatic or robotized.	Advanced problem-solving skills including critical evaluation, allowing to choose the proper technical and economical solutions when applying welding processes and related technologies, in complex and unpredictable conditions.	Manage in detail the welding processes and cutting applications in a highly complex context. Act as the responsible person for the definition of the welding personnel tasks.	6	86	129	10
INTERNATIONAL WELDING SPECIALIST	Specialized and factual knowledge (able to understand and identify) of the principles of welding and cutting processes and applications, either manual, mechanized, automatic or robotized.	Specialised range of cognitive and practical skills, allowing to develop solutions or choose the appropriate methods when applying welding and related technologies in common/regular problems.	Manage and supervise the welding and cutting processes applications in unpredictable modifications. Act as the responsible person for supervise the welding personnel tasks	5	53	80	5
INTERNATIONAL WELDING PRACTITIONER	Factual and theoretical knowledge (basic understand) of the principles of welding and cutting processes and applications, either manual, mechanized, automatic or robotized.	Range of cognitive and practical skills required to identify/choose the proper technical and economical solutions when applying welding and cutting processes on basic and specific problems.	Self-manage the welding and cutting processes applications usually predictable but subject to changes. Will act as the responsible person for supervise the welding personnel tasks	4	32	71	2,5

Module 1: Welding processes and equipment

1.1 General introduction to welding technology				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	3	3	1	1
Scope:	P1	P1	P1	P1
History ……....	X	X	-	-
General applications for welding ……...	X	X	X	X
Schematic presentation of welding processes ……	X	X	X	X
Brief description with characteristics …….....	X	X	-	-
Applicability of the most common welding processes ……...	X	X	-	-
Abbreviations used for welding processes ……..….	X	X	X	X
Hints in use for welding processes ……...	X	X	X	X
Welding positions and Terminology (ISO 6947, ISO 17659)	X	X	X	X
Symbolic representation of joints (overview)……	X	X	X	X
Classification of welding processes (ISO, CEN and national standards).…	X	X	X	X

1.1 General introduction to welding technology – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding regarding the developments in welding processes including accepted terminology, standards and abbreviations	Demonstrate advanced knowledge and skills in describing in detail the welding processes and their range of application including been able to interpret standards related to welding terminology	6	Explain the range of application of most common welding processes providing real and tangible examples for each range of application Associate all welding processes to their common abbreviation and identification code Associate the welding positions to their identification codes Differentiate the weld joints types application	Justify in detail all the differences between each major type of welding process (e.g. fusion arc, resistance, flame, forge, etc.), Explain in detail the application for each weld joint type	Appraise a given welded fabrication case study, analyse its specific application and recommend the welding processes, welding positions and identify if needed alternative solutions	6
IWS & IWP	Apply basic knowledge of the main factors of the different welding processes including terminology, standards and abbreviations	Demonstrate theoretical knowledge and practical skills, in pointing out the major differences between each type of process and referring standards related to welding terminology	4	Outline the range of application of most common welding processes providing concrete examples for each range of application	Point out the most common differences between each main type of welding process (e.g. fusion arc, resistance, flame, forge, etc.), Differentiate the weld joints types application	Evaluate, under limited guidance, with limited autonomy a given welded fabrication case study, pointing out the possible welding processes, welding positions and types of weld joints	2

				Associate the majority of welding processes to their common abbreviation and their identification code Associate the welding positions to their identification codes Identify the application for each weld joint type			3

1.2 Oxy-gas Welding and related processes				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	2	2	1	1
Scope:	P1	P1	P1	P1
Process principles ……	X	X	X	X
Range of Application ……	X	X	X	X
Types of Flames ……	X	X	X	X
Characteristics of fuel gases, (acetylene, propane, etc.) ……	X	X	-	-
Combustion reactions……	X	X	-	-
Temperature distribution effects ……	X	X	-	-
Equipment ……	X	X	X	X
Methods of welding techniques, rightward, leftward ……	X	X	X	X
Standards for filler materials (at least for non-alloy steels)….....	X	X	-	-
Welding applications, typical problems and imperfections……	X	X	X	X
Health and safety issues specific to the process ……	X	X	X	X

1.2 Oxy-gas Welding and related processes – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding regarding the the fundamentals of oxy-gas combustion, characteristics of the different fuel gases, equipment, safety and typical application	Demonstrate advanced knowledge and skills in describing in detail the Oxy-gas application, selecting the consumables (using standards), types of flames, equipment, and how to prevent and solve application problems	6	Describe in detail Oxy-gas welding and related processes characteristics naming its scope of application Explain the features of the three flame types specifying the flames produced by the different fuel gases Characterise the Oxy-gas fuel gases, Flame combustion reactions and flame temperature distribution	Choose equipment for Oxy-gas welding referencing the purpose and working principle of each component of the equipment. Determine the potential hazards and methods of safe handling and working for Oxy-gas welding application.	Appraise a given welded fabrication case study, analyse its specific application and recommend the Oxy-gas welding application conditions and identify, if needed, alternative solutions.	4

				Describe the welding techniques methods application	Define the welding filler material and gases requirements need for a certain application for this process using standards for filler materials and gases.		
IWS & IWP	Apply basic knowledge of the main factors of the fundamentals of oxy-gas combustion, characteristics of different gases, equipment, safety and typical application	Demonstrate fundamental knowledge and skills in outlining the Oxy-gas application, identifying the consumables (using standards), types of flames, equipment, and basic solutions to prevent and solve application problems	4	List all Oxy-gas welding and related processes characteristics naming its most common scope of application Identify the features of the three flame types specifying the major characteristics of flames produced by the different fuel gases List the potential hazards and methods of safe handling and working for Oxy-gas welding simple application Outline the requirements of application for this process using standards for filler materials Outline the welding filler material and gases requirements needed for a certain application for this process using standards for filler materials and gases	Choose equipment for Oxy-gas welding simple application referencing the purpose and working principle of the main components of the equipment.	For a given welded fabrication case, identify the advantages and limitations associated with the use of Oxy-gas welding and, under guidance, point out the possible Oxy-gas application conditions Evaluate with a limited autonomy a given welded fabrication case study, and under guidance pointing out the possible Oxigas application conditions.	2 4

1.3 Electrotechnics				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	1	1	2	2
Scope:	P1	P1	P1	P1
Basics of electricity and electronics (define current, voltage and resistance)……	-	-	X	X
Ohm's Law ……	-	-	X	X
Parallel and serial circuits ……	-	-	X	X
Direct current (DC), polarity, alternating current (AC) ……	-	-	X	X
Magnetism in welding ……	X	X	X	-
Capacity, condenser, Inductance, inductors ……	X	X	X	X
Transformer, and rectifying bridge (half wave and full wave rectification)...	X	X	X	-
Transistor, thyristor, ……	X	X	X	-
Hazard ……	X	X	X	X
Health and safety ……	X	X	X	X

1.3 Electrotechnics – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding regarding basics of electricity in relation to the requirements of welding technology and appreciate the key electronic components used in welding power sources	Demonstrate advanced knowledge and skills in combining all the functions of electric and electronic components in welding power sources and defining the effect of current, voltage and electrical resistance in welding and understand in detail the influence of magnetism in welding.	6	Review the functions of the most important components of welding power sources applying electricity and electronics principles to welding application Discuss the differences between DC and AC current using specific examples of welding application	Describe in detail and explain the effect of current, voltage and electrical resistance in welding. Interpret and apply knowledge regarding electricity, electronics, magnetism in welding application and power sources.	Appraise a given welded fabrication case study, analysing its specific application and discuss the application of type of current, and the effect of magnetism and the welding process electrical parameters and identify if needed alternative solutions.	2
IWS	Apply specialised understanding regarding electricity and the characteristics of the most important electrical components used in electrical welding power sources	Demonstrate specialised knowledge and skills in relating the most important functions of electric and electronic components in welding power sources	5	Describe the relation between current, voltage and electrical resistance, defining each electrical parameter. Explain the major functions of the most important components of welding power sources	Discriminate DC and AC current, providing examples of its application to different welding processes Analyse and apply knowledge related to electricity and electronics in welding application.	Appraise, with reduced direction, a given welded fabrication case study, analysing its specific application and discuss the application of type of current, and the effect of magnetism and the welding process electrical parameters and identify if needed alternative solutions	4
IWP	Apply basic knowledge of electricity and the characteristics of the	Demonstrate fundamental knowledge and skills	4	Outline current, voltage and electrical resistance relating electrical parameter with their international unit	Demonstrate and apply knowledge regarding electricity, electronics,	Evaluate with a limited autonomy a given welded fabrication case	**6**

	most important electrical components used in electrical welding power sources.	in relating the most important functions of electric and electronic components in welding power sources.		Describe the effect of current, voltage and electrical resistance in welding. List the major functions of the most important components of welding power sources. List the major differences between DC and AC current referenced in applications to different welding processes	magnetism in welding applications and power sources.	study, and under guidance pointing out for a specific application the type of current, and the effect of magnetism and the welding process electrical parameters when using a specific welding process.	

1.4 The arc				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	3	3	1	1
Scope:	P1	P1	P3	P3
Arc physics (producing an electric arc, the main arc areas, stability of the arc, gas ionization, ionization potentials, arc forces)……	X	X	X	X
Voltage distribution across the arc ……..…..…	X	X	-	-
Heat generation at the cathode and anode…….……	X	X	X	X
Polarity and arc characteristics in AC and DC and its control for the key welding processes……..……	X	X	X	X
Influence on the welding process ……..……	X	X	X	X
Temperature distribution in the arc and effects...……..…...	X	X	-	-
Influence of the magnetic fields on the arc (why, how to solve)...……	X	X	X	X
Limits of application ……..…….…….……	X	X	X	X

1.4 The arc – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail the fundamentals of an electric arc, its characteristics, limitations and application in welding, including arc stability problems	Demonstrate advanced knowledge and skills in formulating a critical explanation regarding the electric arc characteristics, type of current, and the influence of magnetic fields in electric arc, and proposing solutions for magnetic deflection problems	6	Explain in detail the fundamental physics of an electrical arc, including the main parameters influencing arc stability. Explain the fundamental physics used to define the arc characteristics, e.g. the plasma, temperature profiles, radiation and electrical features' as all arc welds contain these aspects Explain in depth the generation of heat in the arc and the arc voltage distribution. Explain in detail the arc characteristics for DC and AC including control and limitations	Evaluate and diagnose arc welding stability problems, and give solutions for the problems encountered Design original and alternative solutions to magnetic deflection problems	Influence arc welding implementation with the goal to minimise arc instability factors and arc blow Appraise the effect of thermionic emission during arc initialisation, in addition to the type of magnetic flux being either self-induced or as a residual contribution from the type of substrate used.	6
IWS & IWP	Apply basic knowledge of an electric arc, its characteristics, limitations and application in welding	Demonstrate fundamental knowledge and skills in pointing out examples of the electric arc characteristics, type of current, and the magnetic fields in electric arc	4	Describe an electrical arc, naming its main areas and their importance to welding and arc stability. Outline the variety of generation of heat in the arc. Summarise the variety of arc characteristics for DC and AC	Determine solutions to solve simple arc welding instability problems Determine solutions to solve basic and simple magnetic deflection problems	Under limited guidance, give assistance to welders and check welding implementation with the goal to minimise arc blow and instability factors, during arc welding Give assistance to welders and check with limited auton-	2 3

						omy arc welding implementation with the goal, minimising arc instability factors and arc blow during arc welding	

1.5 Power sources for arc welding				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	4	3
Scope:	P1	P1	P3	P3
Power source classification, types and characteristics (static and generators, and each sub-group) ……	X	X	X	X
Power source electrical characteristics (static and dynamic)…..……	X	X	X	X
Relationship between static characteristic and welding process ……..……	X	X	X	X
Control of the electrical static characteristic (flat and drooping)..……..	X	X	-	-
Arc stability for the main processes (MMA, TIG, MIG/MAG, SAW, PAW)...	X	X	X	X
The operation working point ……..…..…	X	X	X	X
Inverter technology (overview, in terms of the most important blocks)……	X	X	X	-
Power sources controlled by a CPU ……..	X	X	X	-
Stability of processes in AC and DC ……..……	X	X	X	-
AC (sine wave and square wave) and DC power sources ……	X	X	X	X
Open circuit voltage, short circuit current, power factor of transformers ….	X	X	X	-
Duty cycle of a power source and typical values for the most common arc welding processes ……..……	X	X	X	X
Voltage losses, relationship between welding current value and cable section……..				
Current and voltage setting (electromagnetic and electronic devices) …….	X	X	X	X
Standards related with welding power sources and their requirements……	X	X	-	-
	X	X	-	-

1.5 Power sources for arc welding – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding regarding the characteristics and main components of arc welding power sources	Demonstrate advanced knowledge and skills in differentiating static and dynamic characteristics for each type of power source and welding process and interpreting the	6	Describe in detail each type of welding power source, the specific static and dynamic electrical characteristics, operation point and control of arc stability.	Explain each type of arc welding power source for both AC and DC, including the most common devices used Discuss the meaning of concepts such as: open circuit	Choose the most suitable power source for a certain arc welding application and/or environment, and implement its correct use	8

		various functions and switches on different power sources			voltage, short circuit current, duty cycle of a power source, voltage losses, and welding current to cable cross section relationship		
IWS	Apply basic knowledge of the main factors related with the components of arc welding power sources	Demonstrate specialised knowledge and skills been able to point out the most common appropriate power sources for a given welding process and the difference between the static and dynamic characteristics	5	Outline the various type of welding power source works (AC and DC), including the most common devices used. Outline for each type of arc welding power source the various static characteristic, operation point and control of arc stability. Recognise the various settings and switches on different power sources and their major effects on the welding process	Give Examples about the meaning of concepts such as: open circuit voltage, arc voltage short circuit current, duty cycle of a power source, voltage losses, and current to cable section relationship Make use of the appropriate power sources for a given welding process.	Check if the welders are using the proper power source for a certain arc welding application and their correct use	6
IWP	Apply basic knowledge of the need of components of arc welding power sources.	Demonstrate fundamental knowledge and skills differentiating the most common appropriate power sources for a given welding process the application and the difference between the static and dynamic characteristics	4	Outline how each type of welding power source works (AC and DC) including the most common devices used. List the most important power source electrical characteristics, such as: open circuit voltage, arc voltage short circuit current, duty cycle of a power source, voltage losses, and current to cable section relationship. Relate the various settings and switches on different power sources and their effects.	Make use of the appropriate power sources for a given welding process.	Check with limited autonomy if the welders are using the proper power source for a certain arc welding application and their correct use	4

1.6 Introduction to gas shielded arc welding

Objective for IWE and IWT: Understand in detail the principles and physical phenomena of gas shielded welding processes.

Objective for IWS and IWP: Gain basic knowledge about the principles of gas shielded welding processes.

Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	2	2	1	1
Scope:	P1	P1	P1	P1
Physical phenomena ……..……	X	X	X	X
Shielding gases (inert, active) and their effect on arc characteristics ……	X	X	X	X
Handling and storage of gases (overview)……..……..	X	X	X	X
Influence of the welding parameters on the weld bead morphology...…..…	X	X	X	X
Standards (ISO, CEN and National) for shielding gases……..…..…...	X	X	X	X

1.6 Introduction to gas shielded arc welding – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail the principles and physical phenomena of gas shielded welding processes	Demonstrate advanced knowledge and skills in relating the applicable arc characteristics with types of shielding gas used for each process and be able to interpreting standards for shielding gases and filler materials	6	Explain in detail the characteristics and operating principles of TIG, MIG/MAG and Flux-cored welding Interpret arc characteristics associated with each type of shielding gas used for each process Interpret the handling and storage requirements of consumables and gases including the safety factors related to handling and storage	Make use of standards for shielding gases and filler materials. Determine the methods for safe handling and storage of shielding gases. Predict the weld bead morphology as a function of the welding parameters and gases used in arc welding	Appraise a given welded fabrication case study, analyse its specific application and recommend the type of gas shielding that should be used and identify if needed alternative solutions Manage and supervise the handling and storage of consumables Manage and assess the activities regarding the choice of gases and filler materials for arc welding processes using shield gases	4
IWS & IWP	Apply basic knowledge about the principles of gas shielded welding processes.	Demonstrate theoretical knowledge and practical skills, in pointing out the major arc characteristics for each type of shielding gas used for each process and be able to use the standards for shielding gases and filler materials	4	Outline the characteristics and operating principles of TIG, MIG/MAG and Flux-cored welding. List arc characteristics associated with each type of shielding gas used for each process. Indicate the major methods for safe handling and storage of shielding gases	Make use of standards for shielding gases and filler materials. Apply the methods for safe handling and storage of shielding gases. Control the weld bead morphology as a function of the welding parameters and gases used in arc welding	Evaluate with limited autonomy, the handling and storage of consumables Verify and check, Evaluate with limited autonomy, the activities regarding the implementation of gases and filler materials for arc welding processes using shied gases For a given material type, apply appropriate international standards requirements to request gas shielding, denoting the chemistry, specification and classification	2

1.7 TIG Welding				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	5	5	3	2
Scope:	P1	P1	P1	P1
Power source characteristics …….……....	X	X	X	X
Methods for arc ignition and necessary equipment ……..…….	X	X	X	X
Equipment and accessories: torches, gas lens, control panel, up and down slope, …….....	X	X	X	X
Effect of current type and polarity: DC(+), DC(-) and AC……..…..	X	X	-	-
Specific requirements for different materials, e.g. Al……..	X	X	X	-
Consumables: shielding gases, filler materials, electrodes ……..	X	X	X	X
Welding parameters: current, voltage, travel speed, gas flow rate……	X	X	X	X
Joint preparation: typical joint design for welding, fit-up, cleaning……	X	X	X	X
Special techniques: pulsed arc, spot-welding, key-hole, hot-wire, orbital welding, tube to tube and tube to sheet, narrow gap and others…….....	X	X	X	-
Standards for filler materials, and electrodes (at least for non-alloy steels).	X	X	X	X
Welding applications, typical problems and how to solve them …….....	X	X	X	X
Health and safety issues specific to the process ……..…..	X	X	X	X

1.7 TIG Welding – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail TIG welding fundamentals, including equipment, application, main variables, safety and specific problems.	Demonstrate advanced knowledge and skills in detailing the range of TIG welding application, including the influence of the welding parameters on the weld bead and all potential problems, proposing a coherent and structured solution for overcoming each identified problem, being able also to interpret standards for filler materials, including the selecting of the type of current, polarity,	6	Explain in detail the principles of TIG welding including arc ignition methods and their application. Discuss the selection of the appropriate type of current, polarity, shielding gas and electrode type according to application. Explain the purpose and functions of each component of the equipment and accessories. Explain all the potential hazards and methods of safe handling and working. Describe the various settings and switches on different TIG power sources and their effects on the welding process	Make use of standards for filler materials Determine the range of application, appropriate joint preparations, electrode type and potential problems to be overcome in TIG application Deduce welding parameters for TIG application Detail the methods of safe handling and working	Appraise a given welded fabrication case study, analyse its specific application and recommend the TIG welding process variables and application conditions and identify if needed alternative solutions Manage and assess the activities regarding the choice of gases, electrodes and filler materials for TIG welding process application Manage and supervise the handling and storage of consumables	10

		shielding gas and electrode type according to the application		Describe the effects of different electrode choices associated with dopants, thermionic emission and correct tip shapes. Define appropriate gas cups and the use of gas lenses		Apply appropriate international standards requirements to specify the correct electrode classification for a particular material, polarity and current.	
IWS	Apply basic knowledge of the TIG welding fundamentals, equipment, application, main variables, safety and specific problems	Demonstrate specialised knowledge and skills being able to identify the appropriate type of current, polarity, shielding gas and electrode according to their application, giving correct examples of the welding parameters and using standards for filler materials	5	Describe the major principles of TIG welding including arc ignition methods and their application. Indicate the range of application, appropriate joint preparations and potential problems to be overcome. Outline the purpose and functions of each component of the equipment and accessories. Indicate the potential hazards and methods of safe handling, storage and working practices. Define the appropriate electrode type, size and correct tip shapes for a particular application. Define appropriate gas cups and the use of gas lenses	Select the appropriate type of current, polarity, shielding gas and electrode type, according to a given application. Establish the welding parameters application. Apply methods of safe handling and working	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance point out the TIG welding process variables and application conditions Verify and check the activities regarding the choice of gases and filler materials for TIG welding processes Verify the handling and storage of consumables Using appropriate international standards, identify the correct electrode for a particular material, polarity and current	6
IWP	Apply basic knowledge of the TIG welding fundamentals, equipment, applications, main variables, safety and specific problem.	Demonstrate a fundamental knowledge and skills in identifying the correct type of current, polarity, shielding gas and electrode according to their application, giving correct examples of the welding parameters proper applications and using standards for filler materials	4	List TIG welding including arc ignition methods and their most common applications. Outline a given standards for consumables. List potential hazards and methods of safe handling and working	Choose the most common applications for each type of current, polarity and electrode Type. Choose the most important applications related with TIG Welding and the appropriate values for welding parameters. Make use and care for TIG welding equipment and accessories. Illustrate with examples TIG applications, joint preparation and potential problems to overcome. Check the activities regarding the implementation TIG Welding processes	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance pointing out the TIG welding process variables and application conditions Evaluate with limited autonomy the handling and storage of consumables	6

					Apply methods for safe handling and working.		

1.8.1 MIG/MAG				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	8	8	6	6
Scope:	P1	P1	P1	P1
Power source characteristics for conventional process and CPU controlled power sources……..	X	X	X	X
Effect of current type and polarity.....	X	X	-	-
Equipment and accessories: torches, wire feeders, hose assembly, control panel…….	X	X	X	X
Metal transfer modes (dip, globular, spray, pulsed and rotating), controlled transfer mode and their application…….....……	X	X	X	X
Welding parameters and settings: current, voltage, travel speed, gas flow rate, etc.....……	X	X	X	X
Consumables: shielding gases, filler materials (solid wires), and their combinations…….....	X	X	X	X
Joint preparation: fit-up, cleaning……..….	X	X	X	X
Special techniques: electro-gas welding, high efficiency processes, spot welding, single wire and multiple wire techniques, flat wire, brazing, electronic stability control (arc and wire feed), etc.....…..	X	X	X	-
Standards for filler materials (at least for non-alloy steels)….....	X	X	X	X
Welding applications, typical problems and how to solve them.....…..….	X	X	X	X
Health and safety specific to the process…..…….....…..…….	X	X	X	X

1.8.1 MIG/MAG – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail MIG/MAG welding fundamentals, including equipment, application, main variables, and common problems	Demonstrate advanced knowledge and skills in detailing the range of MIG/MAG welding application including the influence of the welding parameters on the weld bead and mode of transfer and all potential problems, proposing	6	Explain the principles of MIG/MAG welding including metal transfer modes and their application. Explain the selection of the appropriate type of current, polarity and electrode according to application. Review the influence of the welding parameters on the weld bead	Determine the range of application, appropriate joint preparations and potential problems to be overcome Define potential hazards and determine the methods of safe handling and working Make use of standards	Appraise a given welded fabrication case study, analyse its specific application and recommend the MIG/MAG welding process variables and application conditions and identify if needed alternative solutions	16

		a coherent and structured solution for overcoming each identified problem, being able also to interpret standards for filler materials, including the selecting of the type of current, polarity, shielding gas and electrode type according to the application		Explain the functions of each component of the equipment and accessories. Explain all potential hazards and methods of safe handling and working. Interpret all the appropriate standards consumables	consumables selection Assess the various settings and switches on different MIG/MAG power sources and their effects on the welding process. Deduce welding parameters for particular application. Detail the methods of safe handling and working	Select gases, electrode/filler diameter, current and materials for MIG/MAG welding processes for the type of metal mode transfer. Apply appropriate international standards requirements to identify the correct electrode for a particular material, polarity and current Manage and supervise the handling and storage of consumables	
IWS &IWP	Apply basic knowledge of the MIG/MAG fundamentals, including equipment, application, main variables, safety and common problems	Demonstrate fundamental knowledge and skills, n identifying the appropriate type of shielding gas and electrode according to their application, giving correct examples of the welding parameters and using standards for filler materials	4	Outline the major principles of MIG/MAG welding including metal transfer modes and their application. List the appropriate type of shielding gas and electrode type, according to a given application. Indicate MIG/MAG range of application, appropriate joint preparations and potential problems to be overcome. Recognise the influence of the welding parameters on the weld bead and be able to define the welding parameters for particular applications. Indicate the potential hazards and methods of safe handling, storage and working practices. List the various functions of the main components of the equipment and accessories.	Illustrate with examples how to select the proper consumables for MIG/MAG welding. Apply methods of safe handling and working Make use of appropriate standards for MIG/MAG consumables. Verify the activities regarding the choice of gases and materials for MIG/MAG welding processes Make use and maintain MIG/MAG welding equipment and accessories.	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance point out the MIG/MAG welding process variables and application conditions Evaluate with limited autonomy the handling and storage of consumables	12

1.8.2 Flux Cored Arc Welding				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	2	2	2	2
Scope:	P1	P1	P1	P1
Power source characteristics for conventional process and CPU controlled power sources (only the specific aspects for FCAW)…….……..	X	X	X	X
Effect of current type and polarity.....……..	X	X	-	-
Equipment and accessories: torches, wire feeders..……..……..	X	X	X	X
Relation between the consumables and the type of Metal transfer mode, and their applications……..	X	X	X	X
Welding parameters and settings: current, voltage, travel speed, gas flow rate, etc.....……	X	X	X	X
Consumables: shielding gases, filler materials (flux cored wires), and their combinations…….....	X	X	X	X
Joint preparation: fit-up, cleaning……...……	X	X	X	X
Standards for filler materials (at least for non-alloy steels)….....	X	X	X	X
Welding applications, typical problems and how to solve them…..…..…..	X	X	X	X
Health and safety specific to the process…..…….....…….……	X	X	X	X

1.8.2 Flux Cored Arc Welding – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail FCAW welding fundamentals, including equipment, application, main variables, and common problems	Demonstrate advanced knowledge and skills in detailing the range of FCAW welding application including the influence of the welding parameters on the weld bead and node of transfer and all potential problems, proposing a coherent and structured solution for overcoming each identified problem, being able also to interpret standards for filler materials, including the selecting of the type of polarity, polarity,	6	Explain the principles of Flux Cored Arc Welding including its application. Explain the selection of the appropriate type of polarity and electrode according to application. Review the influence of the welding parameters on the weld bead Explain all potential hazards and methods of safe handling and working. Explain the functions of each component of the equipment and accessories. Interpret all the appropriate standards consumables	Determine the range of application, appropriate joint preparations and present potential problems to be overcome. Define potential hazards and determine the methods of safe handling and working Assess the various settings and switches on different Flux Cored Arc Welding power sources and their effects on the welding process Make use of standards for consumables Deduce welding parameters for particular application.	Appraise a given welded fabrication case study, analyse its specific application and recommend the FCAW welding process variables and application conditions and identify if needed alternative solutions Select correct gases and/or electrode-flux classification and diameter, current and materials for FCAW process in consideration of the type of metal mode transfer. Manage and supervise the handling and storage of consumables	4

		shielding gas and electrode type according to the application					
IWS & IWP	Apply basic knowledge of the FCAW fundamentals, including equipment, application, main variables, safety and common problems	Demonstrate fundamental knowledge and skills in identifying the appropriate type of shielding gas and electrode according to their application, giving examples of the welding parameters and using standards for filler materials	4	Outline the principles of Flux Cored Arc Welding including their most common applications. List the appropriate type of shielding gas and electrode type, according to a given application. Indicate FCAW range of application, appropriate joint preparations and potential problems to be overcome. Recognise the influence of the welding parameters on the weld bead and be able to define the welding parameters for particular applications. Indicate the potential hazards and simple methods of safe handling, storage and working practices. Outline the various functions of the main components of the equipment and accessories.	Illustrate with examples how to select the proper consumables for FCAW Welding. Verify the activities regarding the choice of gases and materials for FCAW Apply methods of safe handling and working. Use of appropriate standards for FCAW consumables. Make use and care for FCAW welding equipment and accessories.	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance point out the FCAW process variables and application conditions Evaluate with limited autonomy the handling and storage of consumables Under limited guidance, select the appropriate gases and/or electrode-flux classification and diameter, current and materials for the FCAW process on the type of metal mode transfer	4

1.9 MMA Welding				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	6	6	4	4
Scope:	P1	P1	P1	P1
Process principles and arc characteristics	X	X	X	X
Effect of current type and polarity	X	X	X	X
Power source characteristics applicable to MMA (open circuit voltage, static and dynamic characteristics, types of current, arc striking methods).	X	X	X	X
Equipment and accessories	X	X	X	X
Process application range, typical problems and how to solve them	X	X	X	X
Covered electrodes (functions of the coating and rod, types of electrodes, slag-metal and gas-metal covered reactions)	X	X	X	X
Production of electrodes (how, typical defects)	X	X	-	-
Handling and storage of electrodes (storage environment, redrying).	X	X	X	X
Standards for filler materials (at least for non-alloy steels).	X	X	X	X
Selection of covered electrodes for their applications	X	X	X	X
Welding parameters: current, voltage, run out length, etc.	X	X	X	X
Joint preparation: fit-up, cleaning, welding position	X	X	X	X
Relationship between electrode diameter and current range, rod material, electrode length and welding position	X	X	X	X
Special techniques (gravity welding, etc.)	X	X	X	X
Health and safety specific to the MMA process	X	X	X	X

1.9 MMA Welding – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail MMA welding fundamentals, including equipment, application, main variables, and common problems	Demonstrate advanced knowledge and skills in detailing the range of MMA welding application including the influence of the welding parameters on the weld bead and all potential problems, proposing a coherent and structured solution for overcoming each identified problem, being able also to interpret standards for	6	Explain the principles of MMA welding including special techniques, arc striking methods and their application. Explain all potential hazards and methods of safe handling and working. Explain the purpose and functions of each component of the equipment and accessories. Review the handling and storage requirements of the various types of electrodes. Interpret all the appropriate standards	Determine the range of application, appropriate joint preparations and potential problems to be overcome Deduce welding parameters for specific application Assess the various settings and switches on different MMA power sources and their effects on the welding process	Appraise a given welded fabrication case study, analyse its specific application and recommend the MMA welding process variables and application conditions and identify if needed alternative solutions Select correct electrode-flux classification and diameter, current and materials for the MMA process in consideration of the type of material being welding and the welding attitude (position).	12

		filler materials, including the selecting of the type of current, polarity, and electrode type according to the application		Review the influence of electrode coating on droplet transfer and weld metal properties	Define potential hazards and determine the methods of safe handling and working Make use of standards consumables selection Deduce welding parameters for particular application.	Manage and supervise the handling and storage of consumables	
IWS & IWP	Apply basic knowledge of the MMA fundamentals, including equipment, application, main variables, safety and common problems	Demonstrate fundamental knowledge and skills, in selecting the type of current, polarity and electrode according to their application, giving examples of the common and appropriate welding parameters for particular application and using standards for filler materials	4	Identify the most common principles of MMA welding Indicate MMA range of application, appropriate joint preparations and potential problems to be overcome. List the potential hazards and methods of safe handling and working. Outline the various functions of each component of the equipment and accessories. Describe the appropriate methods of handling, control and storage of the various types of electrodes. Outline the influence of electrode coating on droplet transfer and weld metal properties	Choose the appropriate type of current, polarity and electrode, according to a given application. Make use of appropriate standards for MMA consumables. Apply methods of safe handling and working Verify the choice of electrode-flux classification and diameter, current and materials for the MMA process in consideration of the type of material being welding and the welding attitude (position).	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance point out the MMA welding process variables and application conditions Evaluate with limited autonomy the handling and storage of consumables	8

1.10 Submerged-Arc Welding				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	6	6	4	4
Scope:	P1	P1	P3	P3
SAW process principles and arc characteristics	X	X	X	X
Effect of current type and polarity	X	X	-	-
Power source characteristics applicable to SAW (open circuit voltage, static and dynamic characteristics, types of current, arc striking methods)				
Equipment and accessories	X	X	X	X
Process application range, typical problems and how to solve them	X	X	X	X
Consumables (functions of the flux and wire -solid or flux cored-, types of flux and wire, wire-flux combination, slag-metal and gas-metal reactions)	X	X	X	X
Production of consumables (how, typical defects)	X	X	X	X
Handling and storage of consumables (storage environment, re-drying)	X	X	X	X
Standards for filler materials wires and fluxes (at least for non-alloy steels)	X	X	X	X
Welding parameters: current, voltage, travel speed, type of flux and particle size, stick-out, etc	X	X	X	X
Joint preparation: fit-up, cleaning	X	X	X	X
Relationship between the wire-flux combination and the characteristics of deposited material	X	X	X	X
One side welding including backing methods	X	X	-	-
Single-wire and multi -wire techniques	X	X	X	X
Special techniques (strip-cladding, iron-powder addition, cold and hot wire addition)	X	X	-	-
Health and safety specific to SAW process	X	X	X	X

1.10 Submerged-Arc Welding – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail SAW welding fundamentals, including equipment, application, main variables, and common problems	Demonstrate advanced knowledge and skills in detailing the range of SAW welding application including the influence of the welding parameters on the weld bead and all potential problems, proposing	6	Explain the principles of SAW process including arc striking methods, special techniques and their application. Review the range of application, appropriate joint preparations and potential problems to be overcome Explain the purpose and functions of each component of the equipment and accessories.	Define the selection of appropriate type of current, polarity and consumable according to application. Deduce welding parameters for particular applications.	Appraise a given welded fabrication case study, analyse its specific application and recommend the SAW welding process variables and application conditions and identify if needed alternative solutions	12

		a coherent and structured solution for overcoming each identified problem, been able also to interpreting		Interpret all the appropriate standards and welding procedures. Explain all potential hazards and methods of safe handling and working. Explaining the influence of the slag-metal and gas-metal reactions on weld metal properties, justifying all the influencing factors and their particular effects;	Define potential hazards and determine the methods of safe handling and working Assess the various settings and switches on different SAW power sources to maintain processing continuity and consistency. Make use of standards consumables selection	Select flux-wire classification and materials used for Submerged-Arc Welding. Manage and supervise the handling and storage of consumables	
IWS & IWP	Apply basic knowledge of the SAW fundamentals, including equipment, application, main variables, safety and common problems	Demonstrate fundamental knowledge and skills in identifying the appropriate type of shielding gas and electrode according to their application, giving examples of the welding parameters and using standards for filler materials	4	Outline the principles of the SAW process including arc striking methods and their applications. Outline the appropriate electrode-flux classification for a particular application Outline the criteria for evaluating the applicable welding parameters. Indicate SAW range of application, joint edge preparation and potential problems to be overcome. Describe the procedures for the set-up of power sources. Recognise the criteria for selecting flux-wire combinations. Identify potential hazards and methods of safe handling and working	Illustrate how to select the proper consumables for SAW Welding. Make use of appropriate standards for SAW consumables. Verify the activities regarding the choice of flux-wire classification and materials for Submerged-Arc Welding Apply methods of safe handling and working	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance point out the SAW welding process variables and application conditions Evaluate with limited autonomy the handling and storage of consumables	8

1.11 Resistance Welding				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	6	6	3	0
Scope:	P3	P3	P3	-
Process principles and overview on types of processes (spot, projection, butt, seam, and flash)……..	X	X	X	-
Joule effect and temperature distribution……..	X	X	X	-
Equipment and accessories …….....	X	X	X	-
Process application range and typical problems (welding thin to thick material, welding of coated/ painted materials, welding dissimilar materials, mass effect, shunt effect, Peltier effect, resistance brazing)……	X	X	X	-
Electrodes (functions, types, shapes, material)……..	X	X	X	-
Electrode classification (ISO, CEN and National standards)…..……	X	X	-	-
Welding parameters: current, pressure, time, type of current, pulse, etc …	X	X	X	-
Joint preparation: typical joint design for welding, fit-up, cleaning ….....	X	X	X	-
Relationship between welding parameters and the characteristics of the weld nugget ……..…….....	X	X	X	-
Monitoring systems, process control, measuring ……..……	X	X	-	-
Specific testing……..	X	X	-	-
Health and safety specific to the resistance welding process..……	X	X	X	-

1.11 Resistance Welding – EARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail resistance welding fundamentals, including equipment, application, main variables, safety, common problems and their solution	Demonstrate advanced knowledge and skills in detailing the range of Resistance Welding applications, appropriate joint preparations and all potential problems, proposing structured solutions for overcoming identified problems, been able also to interpreting related standards;	6	Explain the principles of resistance welding and the application of the various sub-processes. Review the range of application, appropriate material preparation and potential problems to be overcome Explain the purpose and functions of each component of the equipment and accessories. Interpret all the appropriate standards. Explain all potential hazards and methods of safe handling and working.	Define a selection of appropriate parameters to give sound welds Deduce welding parameters for resistance welding applications Define the various settings and conclude about their effects on the welding process Define potential hazards and determine the methods of safe handling and working	Appraise a given welded fabrication case study, analyse its specific application and recommend those Resistance welding process variables and application conditions to produce an acceptable weldment. Select parameter modifications to provide alternative solutions Manage and assess the activities regarding the parameters	12

				Identify the key variables and their interdependencies in producing a weld nugget.	Make use of standards	and settings for resistance welding Select particular electrode materials for a range of applications, with consideration for contact area and profile	
IWS	Apply basic knowledge of the resistance welding fundamentals, including equipment, application, main variables, safety and common problems.	Demonstrate specialised knowledge and skills been able to identify the appropriate range of Resistance Welding application, appropriate joint preparations and the most common problems	5	Outline the principles of the resistance welding process and the application of the various sub processes. Outline the criteria for the selection of the correct pressure and current cycles. Describe the influence of the surface characteristics on the final quality of the joints and the causes of the common discontinuities and their prevention. Indicate welding instructions for welders and operators. Recognise potential hazards and methods of safe handling and working.	Identify the appropriate parameters to give sound welds List the various settings and their effects on the welding process Make use of standards Apply methods of safe handling and working	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance point out the Resistance welding process variables and application conditions Under limited guidance, verify the parameters and settings of resistance welding	6
IWP	NOT APPLICABLE						

1.12.1– Laser; Electron Beam; Plasma				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	8	5	2	1
Scope:	P3	P3	P3	P3
Basic principle of plasma and plasma-MIG welding process and equipment	X	X	X	-
Basic principle of electron beam welding process and equipment)..	X	X	X	-
Basic principle of laser welding process and equipment.....	X	X	X	-
Basic principle of laser- hybrid welding process and equipment	X	X	-	-
Heat generation for each type of process	X	X	X	X
Typical process applications and problems	X	X	X	-
Consumables.....	X	X	X	X
Welding parameters for each process	X	X	X	-
Joint preparation: typical joint design for welding, fit-up, cleaning	X	X	-	-
Relationship between welding parameters and joint configuration	X	X	-	-
Comparison between high energy processes	X	X	X	X
Health and safety specific to the processes	X	X	X	X
Appropriate standards (ISO, CEN and National) for each process.....	X	X	X	-
Plasma Welding……for IWE 2 hours Plasma Welding……for IWT 1 hour				

1.12.1 Other Welding Processes – Laser; Electron Beam; Plasma – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	To apply a highly specialised understanding of those requirements, functions and principles involving plasma; electron beam Laser welding and the fundamentals of each process, including equipment, application, main variables, safety and common problems.	Demonstrate highly specialised knowledge and skills in selecting each type of process according to their application and detailing the welding parameters, joint preparations applicable for Laser; Electron Beam and Plasma welding processes, proposing structured solutions for overcoming each identified problem	7	Explain the principles and application of welding processes, such as: Laser, Electron Beam and Plasma. Describe the purpose and functions of each component of the equipment and accessories. Interpret all the appropriate standards. Explain the purpose and merit of hybrid welding from both sides of laser welding and arc welding	Deduce applications and welding parameters for each type of process, Review the welding parameters, appropriate joint preparations and potential problems to be overcome for each process for a given application Define potential hazards and determine the methods of safe handling and working Apply standards associated with consumables selection, testing and processing variables.	Appraise a given welded fabrication case study, analyse its specific application and recommend the plasma or electron beam or Laser welding processes variables and application conditions and identify if needed alternative solutions	16

IWT	Apply advanced understanding of the principles and the fields of application of plasma; electron beam; Laser welding and the fundamentals of each process, including equipment, application, main variables, safety and common problems.	Demonstrate advanced knowledge and skills in selecting each type of process according to their application and Identifying the welding parameters, appropriate joint preparations and the major potential problems related to Laser; Electron Beam and Plasma welding processes to be overcome.	6	Explain the principles and application of welding processes, such as: Laser, Electron Beam and Plasma. Explain the purpose and functions of each component of the equipment and accessories. Interpret the appropriate standards. Describe the major potential hazards and methods of safe handling and working	Review the welding parameters, appropriate joint preparations and potential problems to be overcome for each process for a given application. Make use of standards consumables selection	Appraise a given welded fabrication case study, analyse its specific application and recommend the plasma or electron beam or Laser welding processes variables and application conditions and identify if needed alternative solutions	10
IWS	Apply basic understanding of the requirements and gain basic knowledge of Plasma; Electron Beam; Laser, their application, main variables and most common problems.	Demonstrate specialised knowledge and skills in identifying the appropriate process and equipment according to a given application and be able to list the welding parameters, appropriate joint preparations handling and working	5	Describe the principles and application of welding processes, such as: Laser, Electron Beam and Plasma. Outline the common applications of the processes in the different industrial fields. Recognise potential hazards and methods of safe handling and working.	Indicate for each process, the suitable welding parameters. Apply methods of safe handling and working	Appraise a given welded fabrication case study, analyse its specific application and recognise Laser, electron beam and plasma application and list the major welding parameters	4
IWP	Apply basic knowledge of Plasma; Electron Beam; Laser, their application, main variables and most common problems.	Demonstrate a fundamental knowledge and skills in identifying the appropriate processes and equipment according to a given application.	4	Identify potential hazards and methods of safe handling and working**.**	Illustrate with examples typical applications of Laser, Electron Beam and Plasma welding processes. Carry out and maintain basic equipment and accessories for the different welding processes (laser, electron beam and plasma).	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance pointing out the Laser, Plasma and Electron Beam process variables and application conditions.	3

1.12.2 Other Welding Processes,				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	6	4	2	2
Scope:	P3	P3	P3	P3
Welding Processes: electro-slag, friction; friction stir, magnetically impelled arc butt (MIAB); magnetic pulse welding, ultrasonic; explosive; diffusion; aluminothermic; high-frequency; stud, cold-pressure welding.				
Basic principles for the processes given in the relevant objective……	X	X	X	X
Heat generation for each type of process ……..……..	X	X	-	-
Equipment and accessories for each type of process ……..……...	X	X	X	X
Typical process applications and problems ……..……	X	X	X	X
Consumables……	X	X	X	-
Welding parameters for each process ……..……	X	X	X	-
Joint preparation: typical joint design for welding, fit-up, cleaning ….....…...	X	X	-	-
Relationship between welding parameters and joint configuration ……..….	X	X	-	-
Health and safety specific to the processes ……..…..	X	X	X	-
Appropriate standards (ISO, CEN and National) for each process.....	X	X	X	X

1.12.2 Other Welding Processes, other than 1.12.1 – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding in detailing the fundamentals and the field of application of electro-slag, friction; friction stir, magnetically impelled arc butt (MIAB); magnetic pulse welding, ultrasonic; explosive; diffusion; aluminothermic; high-frequency; stud, cold-pressure welding, etc. including equipment, main variables and common problems.	Demonstrate highly specialised knowledge and skills in selecting each type of process according to their application and detailing the welding parameters, joint preparations and all potential problems proposing structured solutions for overcoming each identified problem.	7	Explain the principles and application of welding processes, such as: electro-slag, friction; friction stir, magnetically impelled arc butt (MIAB); magnetic pulse welding, ultrasonic; explosive; diffusion; aluminothermic; high-frequency; stud, cold-pressure welding, etc. Explain the purpose and functions of each component of the equipment and accessories. Interpret respective standards.	Deduce application for each type of process Review the welding parameters, joint preparations and potential problems to be overcome for each process for a given application. Define potential hazards and determine the methods of safe handling and working Make use of standards consumables selection	Appraise autonomously a given welded fabrication case study, analyse its specific application and through undertaking a critical review specify, with a mechanical, metallurgical and processing critique the most suitable. Where alternatives are appropriate or needed specify in detail the most suitable solution or solutions.	12
IWT	Apply advanced understanding of the fundamentals and the field of application of electro-	Demonstrate advanced knowledge and skills in selecting each type of pro-	6	Explain the principles and application of welding processes, such as: electro-slag, friction; friction stir, magnetically impelled arc butt (MIAB); magnetic pulse welding, ultrasonic;	Select application for each type of process, and the precautions necessary to achieve a sound weld.	Appraise a given welded fabrication case study, analyse its specific application and recommend a possible welding	8

	slag, friction; friction stir, magnetically impelled arc butt (MIAB); magnetic pulse welding, ultrasonic; explosive; diffusion; aluminothermic; high-frequency; stud, cold-pressure welding, etc. including equipment, main variables and common problems.	cess according to their application and identifying the welding parameters, joint preparations and major potential problems to be overcome.		explosive; diffusion; aluminothermic; high-frequency; stud, cold-pressure welding, etc. Explain the purpose and functions of each component of the equipment and accessories.	Select the parameters, joint preparations and potential problems to be overcome for each process for a given application. Define potential hazards and detail the methods of safe handling and working Make use of standards Associated with consumables selection, testing and processing variables.	process, including the processes variables and application conditions and identify if needed alternative solutions	
IWS &IWP	Apply basic knowledge of the of the fundamentals and the field of application of electro-slag, friction; explosive; diffusion; aluminothermic; high-frequency; cold-pressure welding. Including equipment, main variables and most common problems.	Demonstrate a fundamental knowledge and skills in listing processes principles, application in the different industrial fields;	4	Outline the principles and application of welding processes, such as: electro-slag, friction; friction stir, magnetically impelled arc butt (MIAB); magnetic pulse welding, ultrasonic; explosive; diffusion; aluminothermic; high-frequency; stud, cold-pressure welding, etc. Outline the common application of the processes in the different industrial fields. Recognise potential hazards and methods of safe handling and working.	Apply methods of safe handling and working Identify those standards associated with consumable selection, testing and processing variables	Evaluate with limited guidance a given welded fabrication case study, and point out process variables and application conditions	4

1.13 Cutting, Drilling and other edge preparation processes				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	2	2
Scope:	P1	P1	P3	P3
Survey of edge preparation processes…….……..	X	X	X	X
Mechanical cutting ……	X	X	X	X
Principles of flame and flame powder cutting, equipment, applications and auxiliaries…….….....	X	X	X	X
Flame cutting parameters, edge quality, oxygen purity grades……..…	X	X	X	X
Materials suitable for flame cutting…….……....	X	X	X	X
Basic principles of the various arc cutting processes (air arc, carbon and metal-arc, oxy-arc cutting, gauging with carbon electrode) equipment and auxiliaries…….……..…	X	X	X	X
Materials suitable for arc-cutting, applications, cutting parameters for each process……...	X	X	X	X
Fundamentals of plasma cutting, equipment and auxiliaries…….……	X	X	X	X
Materials suitable for plasma cutting, applications, cutting parameters, cutting gases……	X	X	X	X
Plasma cutting special applications (under water cutting, cutting with water vortex)…….....	X	X	-	-
Plasma gouging…….…….....	X	X	X	X
Fundamentals of electron beam and laser drilling and cutting, equipment, parameters, applications…….……..	X	X	-	-
Fundamentals of water jet cutting, equipment, parameters, applications ...	X	X	X	X
Fundamentals of arc gouging and flame gouging, parameters and applications…….……	X	X	X	X
Appropriate standards (ISO, CEN and National) for each process…..…….	X	X	-	-
Health and safety…….……..	X	X	X	X

1.13 Cutting, Drilling and other edge preparation processes – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail the basic principles and the fields of application of the most common cutting and edge preparation processes used in	Demonstrate advanced knowledge and skills in detailing the range of application for: flame, arc, plasma, electron beam, and water jet cutting, including the influence of	6	Explain the principles of mechanical, flame, arc, plasma, electron beam, laser, and water jet cutting. Discuss the influence of each parameter for the above mentioned processes on the edge surface quality.	Delimit the range of application for: flame, arc, plasma, electron beam, laser and water jet cutting.	Appraise a given welded fabrication case study, analyse its specific application and recommend a cutting process to be used and determine the respective process variables. State any post-processing	8

	weld construction, including equipment, main variables, safety and common problems.	each parameter for the mechanical, flame, arc, plasma, electron beam, laser, and water jet cutting processes on the edge surface quality		Predict the potential risks, hazards and methods of safe handling and working	Define potential hazards and detail the methods of safe handling and working	precautions that should be taken prior to welding. Identify, if needed, suitable alternative solutions	
IWS & IWP	Apply basic knowledge of the basic principles and the fields of application of the most common cutting and edge preparation processes used in weld construction, including equipment, main variables, safety and common problems.	Demonstrate fundamental knowledge and skills in selecting the most common and different edge preparation processes and giving examples of all the characteristic parameters for each process.	4	Describe the principles of mechanical, flame, arc, plasma, electron beam, laser, and water jet cutting. Indicate the characteristic parameters for the above mentioned processes. Classify different edge preparation processes, considering technical and economic aspects. Outline potential risks and hazards related to edge preparation processes.	Apply methods of safe handling and working	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance point out a cutting process to be used and the cutting process variables and conditions	4

1.14 Surfacing and Spraying				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	2	2	1	0
Scope:	P3	P3	P3	-
Working principles and applications for cladding techniques (rolling, explosive, strip, plasma-MIG, electroslag, laser, etc)…….….	X	X	X	-
Basic phenomena (metallurgical and stress) in interface region ……...	X	X	-	-
Consumables for surfacing (cladding)…….….	X	X	-	-
Working principles and applications of the spraying techniques (flame spraying with powder, flame spraying with wire, arc spraying with powder, arc spraying with wire, plasma spraying with powder, HVOF spraying, cold gas)……...	X	X	X	-
Equipment and parameters for each technique…….……..….	X	X	X	-
Surface preparation of the base material…….……	X	X	X	-
Spraying materials…….……...	X	X	X	-
Sprayed layer structure, and substrate structure…….…….……..	X	X	-	-
"Cold " and "fusion" spraying techniques…….…….....	X	X	-	-
Applications and special problems…….……	X	X	X	-
Standards for surface treatment and processes for spraying of materials…	X	X	X	-
Health and safety.....	X	X	X	-

1.14 Surfacing and Spraying – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail the principles and fields of application of the most common surfacing techniques and their working principles, including equipment, main variables, safety and common problems.	Demonstrate advanced knowledge and skills in detailing the range of the most common surfacing spraying techniques and predicting the quality of a surfacing layer, indicating how the base material preparation influences the quality of the interface and structure.	6	Explain the principles and characteristics of the most common cladding and spraying techniques. Review the range of applications of "cold" and "fusion" spraying techniques. Review the most common spraying techniques and their industrial applications Predict the potential risks, hazards and methods of safe handling and working	Define potential hazards and detail the methods of safe handling and working Interpret standards associated with consumable selection, testing and processing variables	Appraise a given fabrication case study, analyse its specific application and recommend a surfacing or spraying process that should be used, along with the respective process variables. State the pre-processing precautions that should be taken prior to surfacing to ensure integrity. Identify, if needed, suitable alternative solutions	4
IWS	Apply basic understanding of the requirements and gain basic knowledge of the principles and fields of application of the most common surfacing techniques and their working principles, including equipment, main variables, safety and common problems.	Demonstrate specialised knowledge and skills in identifying the most common surfacing and spraying techniques	5	Describe the characteristics of the most common cladding and spraying techniques. Describe the influence of surface preparation on spraying procedures. Indicate the most common spraying techniques and their industrial applications. Identify those standards associated with consumable selection, testing and processing variables	Apply methods of safe handling and working	Evaluate with a limited autonomy a given fabrication case study, and under guidance point out surfacing an spraying techniques and surface preparation needed.	2
IWP	NOT APPLICABLE						

1.15 Fully mechanised processes and robotics				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	8	6	4	0
Scope:	P3	P3	P3	-
Survey of welding mechanisation for higher productivity ……..……	X	X	X	-
Robotics, mechanisation, and automation: differences, advantages disadvantages and applications..……..……	X	X	X	-
Robotics (on-line and off-line programming, simulation, flexible manufacturing systems) ...……..	X	X	X	-
CAD/CAM systems……..……..	X	X	-	-
Virtual factory (factory simulation)…….……..	X	X	-	-
Seam tracking, types and typical applications…….……	X	X	-	-
Gas nozzle sensor, arc sensing, magnetic induction, vision system ……..	X	X	X	-
Narrow gap welding (SAW, MIG/MAG, TIG) …….....	X	X	X	-
Orbital welding (MIG/MAG, TIG) …….....	X	X	-	-
Additive manufacturing (3D printing)……	X	X	-	-
Typical robot type depending upon application field……	X	X	X	-
Application, typical problems and how to solve them…….….....	X	X	X	-
Health and safety…….……..	X	X	X	-

1.15 Fully mechanised processes and robotics – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding in detail the principles and industrial application of welding mechanisation and the use of robotics in welding, including application and systems.	Demonstrate highly specialised knowledge and skills in selecting the best solution for higher productivity in welding using robotics, automation and mechanisation, justifying all its strengths and limitations.	7	Explain the principle, benefits and application of each type of seam tracking system and of narrow gap and orbital welding. Review different applications for each welding process when applied to narrow gap or orbital welding. Discuss in a comprehensive way the use and advantages of a robot type system within an application field	Predict the best solution for higher productivity in welding using robotics, automation and mechanisation. Predict the potential risks, hazards and methods of safe handling and working.	Appraise a given welded fabrication case study, analyse its specific application and justify mechanised or automation or robotic application solution and identify if needed alternative solutions	16
IWT	Apply advanced understanding of the principles and the and industrial application of welding mechanisation and the use of robotics in welding, including application and systems.	Demonstrate advanced knowledge and skills in selecting solutions for higher productivity in welding using robotics, automation and mechanisation.	6	Explain the differences between off-line and on-line programming. Explain the principle, benefits and application of each type of seam tracking system and of narrow gap and orbital welding.	Select solutions for higher productivity in welding using robotics, automation and mechanisation. Define the potential risks, hazards and methods of safe handling and working.	Appraise a given welded fabrication case study, analyse its specific application and recommend mechanised or automation or robotic application solution and identify if needed alternative solutions	12

				Compare the different applications for each welding process when applied to narrow gap or orbital welding. Describe the major potential risks, hazards and methods of safe handling and working. Explain robot type concerning application field.			
IWS	Apply basic understanding of the requirements and gain basic knowledge of the principles and industrial application of welding mechanisation and the use of robotics in welding, including application and systems	Demonstrate specialised knowledge and skills in listing the techniques and apparatus for higher productivity in welding using robotics, automation and mechanisation.	5	Outline the advantages and disadvantages of robotics, automation and mechanisation of welding processes. Point out the techniques used for seam tracking and their differences. Indicate the features of the most common industrial applications (e.g. narrow gap and orbital welding). Outline potential risks, hazards and methods of safe handling and working related with automatic, mechanised and robotics in welding processes.	Apply solutions for higher productivity in welding using robotics, automation and mechanisation. List the potential risks, hazards and methods of safe handling and working.	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance point out the possible application for mechanised, automation and robotic application	8
IWP	NOT APPLICABLE						

1.16 Brazing and soldering				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	2	0
Scope:	P3	P3	P3	-
Fundamentals of brazing and soldering (bonding mechanisms, surface tension, wetting, capillary action) ……	X	X	X	-
Survey of brazing and soldering techniques, equipment, range of applications ……..……	X	X	X	-
Consumables and fluxes for brazing and soldering, types, applications, and main functions of the fluxes …….	X	X	X	-
Materials suitable for brazing, brazing requisites ……..……..	X	X	X	-
High vacuum brazing, brazing under controlled atmosphere …….....	X	X	X	-
Braze welding (Arc and laser brazing)……....	X	X	X	-
Survey of soldering techniques (dip, wave flow, vapour phase)…….....	X	X	X	-
Brazing and soldering advantages and disadvantages ……..……	X	X	X	-
Applications and special problems ……..….	X	X	X	-
Overview on standards……...….	X	X	X	-
Health and safety ……	X	X	X	-

1.16 Brazing and soldering – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail the fundamentals and the field of application of brazing and soldering, main variables, safety, equipment, application, and common problems.	Demonstrate advanced knowledge and skills in deducing different application for each brazing and soldering technique, also detailing the need actions to obtain a sound joint using brazing or soldering techniques and comparing each type of brazing and soldering technique with fusion welding	6	Explain each brazing and soldering technique. Review need actions to be implemented to obtain a sound joint using brazing or soldering techniques. Describe the types and characteristics of consumable and flux used in certain applications. Explain all potential hazards and methods of safe handling and working.	Deduce the different applications for each brazing and soldering techniques, including joint preparations and potential problems to be overcome Predict the potential risks, hazards and methods of safe handling and working	Appraise a given fabrication case study, analyse its specific application and recommend if a brazing or soldering process should be used along with the respective process variables. State the pre-processing precautions that should be taken prior to brazing or soldering to ensure integrity. Identify, if needed, suitable alternative processing solutions.	8
IWS	Apply basic knowledge of the fundamentals and the field of application of brazing and soldering, main variables, safety,	Demonstrate specialised knowledge and skills in describing the most relevant application for each brazing and soldering	5	Describe the different techniques for brazing and soldering. Indicate the standard operating procedures for brazing and soldering techniques.	Apply those standards requirements associated with consumable selection, testing and processing variables	Under limited guidance, evaluate a given fabrication case study, and set out the preparation required for application of brazing and soldering	4

	equipment, application, and common problems.	techniques, including main variables application and common problems		Outline the influence of surface preparation on brazing and soldering techniques. Describe the various the types and characteristics of consumables and fluxes employed. List the appropriate brazing or soldering variables for a given application. Outline potential risks, hazards and methods of safe handling and working.	Apply methods of safe handling and working		
IWP	NOT APPLICABLE						

1.17 Joining processes for plastics				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	2	0
Scope:	P3	P3	P3	-
General information on materials and joining processes …….……..	X	X	X	-
Study the operating principle for each type of process ……..……	X	X	X	-
Hot plate welding, butt fusion, hot gas welding, extrusion welding, induction welding, resistance welding, implant welding, high frequency, friction, electro-fusion welding, ultrasonic welding, vibration welding, adhesive bonding ……..	X	X	X	-
Control of welding parameters, types of equipment, joint design …….	X	X	X	-
Advantages and disadvantages …….	X	X	X	-
Applications and typical problems and how to solve them …….	X	X	X	-
Health and safety ……..	X	X		-

1. 17 Joining processes for plastics – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding in detail the principles involved in joining plastics, includ-	Demonstrate advanced knowledge and skills in detailing all the different application for each joining process, indicating its strengths and limitations,	6	Explain the fundamentals of each joining process. Discuss the precautions necessary to obtain a sound joint for each process.	Review the different applications for each joining process. Predict the potential risks, hazards and methods of safe handling and working	Appraise a given welded fabrication case study, analyse its specific application and recommend the welding process, process variables, application	8

	ing the common techniques, equipment, application, main variables, safety and common problems.	and predicting the precautions necessary to obtain a sound joint for each process.				conditions and identify if needed alternative solutions	
IWS	Apply basic knowledge of the principles involved in joining plastics, including the common techniques, equipment, application, main variables, safety and common problems.	Demonstrate specialised knowledge and skills in selecting the common industrial application for each joining process	5	Identify the basic characteristics and the range of application for each joining process. Describe the operating principle of the most common joining processes. Indicate the state of the art of the industrial applications for each joining process. Outline potential risks, hazards and methods of safe handling and working.	List the operating variables of the most common joining processes. Apply methods of safe handling and working	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance point out the plastic welding processes technique and application.	4
IWP	NOT APPLICABLE						

1.18 Joining processes for ceramics and composites				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	1	1	0	0
Scope:	P3	P3	-	-
General information on ceramics and composites and typical joining processes……..	X	X	-	-
General study of the operating principles for each process.....	X	X	-	-
Advantages and disadvantages……	X	X	-	-
Applications and special problems……	X	X	-	-

1.18 Joining processes for ceramics and composites – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply basic knowledge of the general principles of joining ceramics and composites, including the common techniques (diffusion bonding, braz-	Demonstrate specialised knowledge and skills in selecting the proper joining technique to each type of ceramics and composites	6	Explain the fundamentals of joining ceramics and composites. Discuss in a comprehensive way about the precautions to be taken to obtain a sound joint.	Predict the potential risks, hazards and define methods of safe handling and working Deduce the different applications for each joining process applied to the type of sub-	Appraise a given fabrication case study, analyse its specific application and recommend a process solution for joining ceramics or composites including the application conditions and identify if needed alternative solutions	2

	ing and soldering, ultrasonic, adhesive bonding, etc.), application, and common problems.			Outline the influence of surface preparation on joining technique success for each type of process. Describe the various types and characteristics of consumables and activators employed for joining these materials	strate, including joint preparations and potential problems to be overcome.		
IWS & IWP	NOT APPLICABLE						

1.19 Welding laboratory				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	10	8	6	0
Scope:	P3	P3	P3	-
Practical exercises showing the effect of each main welding parameter on the weld bead shape…….……..	X	X	X	-
Discussion of results to help future evaluation and diagnosis…….……..	X	X	X	-
Exercises should cover: MMA, TIG, MIG/MAG, Flux Cored wires, SAW, Oxy-gas……..	X	X	X	-
Practical exercises showing the effect of each main cutting parameter on the cut surface…….……..	X	X	X	-
Exercises should cover: Oxy-cutting, Arc-Air, Plasma, Arc-Cutting Welding simulation can be used as replacement				

1.19 Welding laboratory – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding the effect of parameters on weld bead shape and cut surface quality.	Demonstrate highly specialised knowledge and skills in predicting weld bead shape, morphology, and cutting surfaces, based in the processes parameters used.	7	Explain in detail the factors that influence the weld bead morphology (internal and external) and the cut surface quality according to the welding/cutting parameters used.	Evaluate weld beads and cut surfaces, in order to predict process problems Specify through using international standards the optimum technique to prepare and analyse samples to maximise knowledge transfer. Prepare sampling documentation and professional laboratory report data	Appraise a given welded fabrication case study, analyse its specific application and prevent the incorrect weld bead shapes, morphologies and cutting surfaces	10

IWT	Apply advanced understanding of the effect of parameters on weld bead shape and cut surface quality.	Demonstrate advanced knowledge and skills in deducing weld bead shape, morphology, and cutting surfaces, based in the processes parameters used.	6	Explain the factors that influence the weld bead shape and morphology (internal and external) or cutting surface, according to the welding/cutting parameters used.	Assess weld beads and cut surfaces, in order to deduce process problems Through using international standards specify a preparation technique to maximise knowledge transfer	Appraise a given welded fabrication case study, analyse its specific application to prevent the formation of incorrect weld bead shapes, morphologies and cutting surfaces	8
IWS	Apply basic knowledge of the effect of parameters on weld bead shape and cut surface quality.	Outlining the common welding and cutting parameters involved, their set-up, effect and how to check them during welding, in accordance with the applicable procedures;	5	Demonstrate specialised knowledge and skills in identifying weld bead shape and morphology and cutting surfaces as a function of the welding/cutting parameters used.	Analyse weld beads and cut surfaces, in order to determine process problems	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance point out the possible problems regarding the weld bead shape and cutting surfaces due to the welding/cutting parameters used.	6
IWP	NOT APPLICABLE						

Module 1 - Welding processes and equipment

Module 1	**IWE**		**IWT**		**IWS**		**IWP**	
	MT	**P1 ***	**MT**	**P1 ***	**MT**	**P1 ***	**MT**	**P1 ***
Teaching Hours	**95**	**46**	**86**	**46**	**53**	**20**	**32**	**19**

***** P1 = Part 1, Figures under P1 are given for the Standard Route (see 4.1)

Module 2: Materials and their behaviour during welding

Characterization of the general description of Module 2 – Materials and their behaviour during welding, describing the Qualification descriptors in terms of Knowledge – K, Skills – S, Competences - C for each IIW welding coordination qualification

COMPETENCE UNIT 2: MATERIALS AND THEIR BEHAVIOUR DURING WELDING							
QUALIFICATION	**KNOWLEDGE**	**SKILLS**	**COMPETENCES**	**EQF LEVEL (EQF L)**	**TEACHING HOURS**	**WORKLOAD (WL)**	**ECVET POINTS**
INTERNATIONAL WELDING ENGINEER	Highly specialized knowledge (able to deduce, detail and explain) and critical assessment regarding materials processing and applications and their behaviour during welding and cutting.	Highly specialized skills including critical evaluation (able to predict and deduce), to determine the correct technical solutions in terms of materials processing by welding and cutting and be able to find solutions and predict problems due to the materials behaviour during welding in complex and unpredictable conditions	Manage in detail the materials applications and their behaviour due to welding and related technologies in a highly complex context. Act as the responsible person for the definition of the welding personnel tasks	7	115	230	20
INTERNATIONAL WELDING TECHNOLOGIST	Advanced knowledge (able to deduce, detail and explain) and critical assessment regarding materials processing and applications and their behaviour during welding and cutting.	Advanced skills including critical evaluation (able to predict and deduce), to determine the correct technical solutions in terms of materials processing by welding and cutting and be able to find solutions and predict problems due to the materials behaviour during welding in complex and unpredictable conditions	Manage in detail the materials applications and their behaviour due to welding and related technologies in a highly complex context. Act as the responsible person for the definition of the welding personnel tasks	6	96	192	20
INTERNATIONAL WELDING SPECIALIST	Specialized and factual knowledge (able to understand and identify) regarding materials processing and applications and their behaviour during welding and cutting.	Specialised range of cognitive and practical skills which will allow choosing the proper technical solutions in terms of materials processing by welding and be able to develop solutions due to the materials behaviour during welding on common/regular problems.	Manage and supervise the materials applications and their behaviour due to welding and related technologies in unpredictable modifications. Act as the responsible person for supervise the welding personnel tasks	4	56	112	10
INTERNATIONAL WELDING PRACTITIONER	Factual and theoretical knowledge (basic understand) regarding materials processing and applications and their behaviour during welding and cutting.	Range of cognitive and practical skills required to identify/choose the proper technical solutions in terms of materials processing and materials behaviour during welding and cutting on basic and specific problems.	Self-manage the materials applications and their behaviour due to welding and related technologies usually predictable but subject to changes. Will act as the responsible person for supervise the welding personnel tasks	4	23	54	2

2.1 Structure and properties of metals				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	2	0
Scope:	P1	P1	P1	
Crystalline structures	X	X	-	-
Crystal lattice structure types and imperfections	X	X	-	-
Deformation (Elastic/plastic)	X	X	X	-
Cold and hot deformation	X	X	X	-
Work hardening and strain ageing	X	X	X	-
Recrystallization	X	X	X	-
Properties (influence of temperature, loading speed, environment)	X	X	X	-

2.1 Structure and properties of metals – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the structure and properties of metallic materials subjected to the special process of welding	Demonstrate advanced knowledge of the structure and properties of metallic materials	6	Explain the structures of metallic materials. Compare the properties of metals as structural materials. Interpret the changes in the crystallographic structures of metals due to cold deformation and recrystallization. Explain the effects of loading conditions on the properties of structural materials	Predict the changes in the crystallographic structures of metals following welding		8
IWS	Apply understanding of the principles of the structure and properties of metallic materials subjected to the special process of welding.	Demonstrate specialised knowledge and skills in the structure and properties of metallic materials	4	Describe the structures of pure metals and alloys Identify the basic mechanical properties of metals Outline the effect of loading conditions on the properties of metallic materials	Categorise the mechanical properties of metallic materials according to their structures.		4
IWP	NOT APPLICABLE						

2.2 Phase Diagrams and Alloys				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	2	2
Scope:	P1	P1	P1	P1
Pure metals and alloys	X	X	X	X
Alloying elements	X	X	X	X
Binary diagrams (basic types, non-, fully- and partly soluble components)	X	X	X	X
Ternary diagrams	X	-	-	-
Solidification, segregation and coring	X	X	-	-
Structure of alloys	X	X	X	X
Structure of castings	X	X	-	-
Solutions (solid, interstitial,)	X	X	-	-
Intermetallic compounds	X	X	-	-
Solid state transformations	X	X	-	-
Equilibrium and non equilibrium transformations	X	X	-	-
Strengthening mechanisms (solid solution, precipitation, grain size)	X	X	X	X
Ageing	X	X	X	X
Mechanical properties versus microstructure	X	X	X	X

2.2 Phase Diagrams and Alloys – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the principles of alloying, the structures of alloys, phase diagrams and compounds in diagrams	Demonstrate advanced knowledge and skills in the use of Phase Diagrams	6	Interpret crystalline lattice distortion from given alloying elements and subsequent structural changes. Explain, in detail, solidification structure and segregation. Compare the mechanisms of precipitation, types of precipitates and their location within the microstructure. Explain, in detail, the principles of transformation and conditions under which it occurs. Explain the relationship between microstructure, phase diagrams and mechanical properties.	Produce relevant examples to illustrate solidification structure and segregation. Produce relevant examples to illustrate the principles of strengthening mechanisms. Apply phase diagrams to define microstructures, mechanical properties and alloys.		8

				Explain the principles of phase diagrams, and their construction. Exemplify basic types of alloy systems			
IWS & IWP	Apply basic knowledge of the principles of alloying, the structures of alloys phase diagrams and compounds in diagrams	Demonstrate fundamental knowledge and skills in the application of principles of Phase Diagrams	4	Recognise solidification structure and segregation in relevant examples. Outline the most common principles of strengthening mechanisms with appropriate examples. Summarise the relationship between microstructure and binary phase diagrams. Describe alloys and binary phase diagrams	Select alloy microstructures from given phase diagrams		6

2.3 Iron – carbon alloys				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	5	5	3	1
Scope:	P1	P1	P1	P1
Iron solidification and changes in solid state.....	X	X	X	X
Fe-C equilibrium diagram.....	X	X	X	X
Microstructure of Fe-C alloys (pearlite, ledeburite, etc.)…….……	X	X	X	-
Influence of alloying elements on the Fe-C equilibrium diagram……....	X	X	X	-
Carbide forming elements ……..…...	X	X	X	X
Iron-alloys with closed gamma-loop, with broadened gamma-area……....	X	X	-	-
Influence of cooling rate, hardenability.....	X	X	X	X
TTT and CCT diagrams.....	X	X	X	X
Influence of alloying elements on TTT diagrams.....……	X	X	-	-
Grain growth effect.....	X	X	X	-
Classification of heat treatment.....	X	X	X	X

2.3 Iron – carbon alloys – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the metallurgical processes occurring in welding of iron carbon alloys	Demonstrate advanced knowledge and skills in the metallurgy of welded iron carbon alloys	6	Infer the Fe-C system from a CCT diagram Compare the influences of alloying elements and cooling rate on microstructure	Predict the microstructure from a CCT diagram		10

				Exemplify the structures occurring in rapid cooling Explain the process and consequences of grain growth Classify, in detail, the effect of heat treatment on microstructure			
IWS	Apply understanding of the principles of alloying, the structures of alloys, phase diagrams and compounds in diagrams	Demonstrate specialised knowledge and skills in the use of Phase Diagrams	5	Recognise Fe-C alloy structures Describe the influence of cooling rate on alloy microstructure regarding material hardenability Describe prevention of coarse structure Classify heat treatment	Select Fe-C alloys from a CCT diagram		6
IWP	Apply basic knowledge about the metallurgical processes occurring in welding of iron carbon alloys.	Demonstrate fundamental knowledge and skills in the metallurgical processes, applying them to welding of iron carbon alloys.	4	Identify phases in the Fe-C diagram. Identify carbide forming elements. Outline special items in the Fe-C diagram (types of Fe-C alloys) Outline the most common influence of cooling rate, hardenability. Name and classify simple cases of heat treatment	Read simple TTT and CCT diagrams Compare hardness of steel according to their composition and cooling rate Check iron solidification and microstructure in solid state of iron. Check the Fe-C equilibrium diagram.	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance pointing out the most common problems regarding the weldability of iron carbon alloys	**3**

2.4 Manufacture and classification of steels				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	2	2
Scope:	P1	P1	P1	P1
Introduction to metallurgy of steels	X	X	-	-
Steel making processes (furnaces, convertors, deoxidation, etc.)	X	X	-	-
Processing of steel products (hot, cold rolling, casting, etc.)	X	X	X	X
Chemical composition and impurities	X	X	X	X
Properties of steels	X	X	X	X
Discontinuities and defects in steel	X	X	X	X
Classification of steel (purpose of use, ISO/TR 15608)	X	X	X	X
Designation of steels (National, EN Standards, Wr. No.)	X	X	X	X
Steel products (plates, tubes, profiles)	X	X	X	X
Inspection Certificate (i.e. EN 10204)	X	X	X	X

2.4 Manufacture and classification of steels – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the fundamentals of steels, production, their properties and composition, classification and standardization, and steel semi-products	Demonstrate advanced knowledge and skills in the manufacture and classification of steels	6	Explain the basic technology of steel production Compare the influence of impurities and chemical composition on basic mechanical properties Explain how steel is processed by rolling and casting Compare the properties of steel semi-products Interpret standards for steel designation and standards on rolling products	Discuss differing types of steel, particularly structural steels Decide on acceptance methods and types of inspection documents		8
IWS & IWP	Apply basic knowledge on the fundamentals of steels, production, their properties and composition, classification and standardization, and steel semi-products	Demonstrate fundamental knowledge and skills in the manufacture and classification of steels	4	Describe how steel is processed by rolling and casting Identify the most common properties of steel semi-products Identify types of inspection documents Identify and interpret inspection certificates (i.e EN 10204).	Categorise types of steel, particularly structural steels Apply standards for steel designation and standards on rolling products		4

2.5 Behaviour of structural steels in fusion welding				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	2	2
Scope:	P1	P1	P1	P1
Thermal field …….…….……..	X	X	-	-
Heat input and efficiency of heat input…….……..	X	X	X	X
Peak temperature …….……..	X	X	X	X
Cooling rate and thermal cycle, $\Delta t_{8/5}$…….……..	X	X	X	X
Heat flow.....	X	X	X	X
Heat-affected zone (grain growth and grain refinement, CCT diagrams).....	X	X	X	X
Properties of HAZ.....	X	X	X	X
Carbon equivalent.....	X	X	X	X
Weld pool, weld shape.....	X	X	X	X
Dilution …….…….……..	X	X	-	-
Structure of weld metal.....	X	X	X	X
Effect of multi-pass welding.....	X	X	X	X
Equations for the heat distribution…….……..	X	X	-	-
Weld metal structure (weld protection, consumables, etc.)…….……..	X	X	X	X
Solidification of weld pool…….….	X	X	X	X
Relationship grain size – toughness…….……..	X	X	X	X
Transition temperature…….……..	X	X	X	X

2.5 Behaviour of structural steels in fusion welding – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the metallurgical fundamentals of welding of all types of structural steels	Demonstrate advanced knowledge and skills in the metallurgy of welded structural steels	6	Explain the temperature distribution in welds and the microstructure formed as a result of welding. Infer the effects of the weld protection and the type of consumable on the microstructure of weld metal and on its properties for a single-pass weld versus a multi-pass weld. Compare the areas of the HAZ, the grain size and microstructural changes for a single-pass weld versus a multi-pass weld. Explain the various aspects of weldability.	Predict the effects of heat input, cooling rate and multi-pass operation on weld metal solidification and the microstructure formed for a single-pass weld versus a multi-pass weld. Predict the effects of microstructural changes in the HAZ on properties for a single-pass weld versus a multi-pass weld.	Appraise a non-complex structural steel joints involving single pass and multi pass welds and recommend the heat input and thermal management required to minimise residual stress and avoid cold-cracking	8

IWS &IWP	Apply basic knowledge of the principles of the metallurgical fundamentals of welding of all types of structural steels	Demonstrate fundamental knowledge and skills in the metallurgy of welded structural steels	4	Describe the temperature distribution in welds Identify the microstructure formed in a single pass weld versus a multi-pass weld. Associate the effects of the weld protection and the type of consumables on the microstructure of the weld metal with the properties for a single pass weld versus a multi -pass weld. Identify areas of HAZ, the reasons for grain size and microstructural changes and their effects on properties for a single pass weld versus a multi-pass weld.	Categorise the various aspects of weldability	Evaluate a non-complex structural steel joints and, under limited guidance, recommend the application of heat treatment and single or multi pass welds to minimise residual stress and avoid cold-cracking.	4

2.6 Cracking phenomena in welded joints				
Qualification	***IWE***	***IWT***	***IWS***	***IWP***
Teaching hours	8	6	4	2
Scope:	P3	P3	P3	P3
For unalloyed, heat resistant and stainless steels as appropriate:				
Cold cracking:				
Cracking mechanisms in weld metal and HAZ, causes and avoidance……	X	X	X	X
Effect of hydrogen…….	X	X	X	X
Source and diffusion of hydrogen …….	X	X	X	X
Control of hydrogen …….	X	X	X	X
Effect of microstructure……	X	X	X	X
Susceptible microstructure and its control …….	X	X	X	X
Influence of alloying elements on susceptibility …….	X	X	X	X
Effect of stresses……	X	X	X	X
Influence of restraint …….	X	X	X	X
Influence of preheat …….	X	X	X	X
Influence of austenitic weld metal …….	X	X	X	X
Testing of cold cracking susceptibility……..	X	X	-	-
Determination of preheat and interpass temperature (diagrams) ISO/TR 17671-2 and ISO 13916 …….	X	X	-	-
Hot cracking:				
Cracking mechanisms in particular in weld metal and in HAZ (solidification cracking, liquation cracking, etc.); causes and avoidance …….	X	X	X	X
Effect of alloy elements, heat input, bead shape, nugget shape……	X	X	X	X

Liquation phases……..	X	X	X	X
Avoidance of hot cracking, ISO/TR 17671-2……..	X	X	X	X
Testing for hot cracking susceptibility	X	X	-	-
<u>Reheat cracking:</u>				
Cracking mechanisms in weld metal and HAZ; causes and avoidance..…	X	X	X	X
Type of steels sensitive to reheat cracking	X	X	X	X
Effect of alloy elements, thermal cycles, stress….....	X	X	X	-
Cracking during heat treatment and multi -pass welding ….....	X	X	X	X
Avoidance of reheat cracking…….....	X	X	X	X
Testing for reheat cracking susceptibility …….....	X	X	-	-
<u>Lamellar tearing:</u>				
Cracking mechanism; causes and avoidance	X	X	X	X
Effects of inclusions, joint configuration, stress	X	X	X	X
Control of lamellar tearing by material choice and joint configuration ISO/TR 17671-2……	X	X	X	X
Testing for susceptibility (through-thickness properties)…….....	X	X	-	-
Steels with increased resistance to lamellar tearing.....	X	X	X	X
<u>General:</u>				
parametric equations for cracking sensitivity evaluation ……..	X	X	-	-
morphology of individual crack types ……..	X	X	-	-
Standards for crack sensitivity testing ……..	X	X	-	-

2.6 Cracking phenomena in welded joints – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the fundamentals of various cracking mechanisms in welded joints, the way in which welding variables affect the incidence of cracking, and methods of avoidance	Demonstrate highly specialised knowledge and skills in avoidance of cracking in welds	7	Explain in detail the metallurgical mechanisms for each of the major types of cracking. Infer the type and cause of cracking from study of fractured material and its history. Compare alternatives that will reduce or eliminate the occurrence of lamellar tearing in welded construction/fabrication. Relate the effects of inclusions, joint configuration, stress and fatigue on susceptibility to weld cracking. Relate changes in welding variables to the control of cracking of welds.	Predict the effects of chemical and physical variables for each of the major types of cracking. Decide on appropriate precautions to avoid variations in key welding parameters causing cracking Justify the tests that will assist in finding the solution of cracking problems.	Appraise a welded joint and recommend the methods that may be applied to determine and control the welding variables to avoid cracking	16

IWT	Apply advanced understanding of the fundamentals of various cracking mechanisms in welded joints, the way in which welding variables affect the incidence of cracking, and methods of avoidance	Demonstrate advanced knowledge and skills in avoidance of cracking in welds	6	Compare the metallurgical mechanisms for each of the major types of cracking. Explain the effects of chemical and physical variables for each of the major types of cracking. Compare susceptibility to cracking by reference to the key welding parameters Infer the type and cause of cracking from study of fractured material and its history. Compare the effects of inclusions, joint configuration, stress and fatigue on weld cracking. Explain methods of control of weld cracking.	Select suitable tests that will assist in finding the solution of cracking problems. Select alternatives that will reduce or eliminate the occurrence of lamellar tearing in welded construction/fabrication. Assess appropriate precautions to avoid cracking.	Appraise a welded joint and select options that may be applied to determine and control the welding variables to avoid cracking	12
IWS	Apply understanding of the fundamentals of various cracking mechanisms in welded joints, the way in which welding variables affect the incidence of cracking, and methods of avoidance	Demonstrate specialised knowledge and skills in avoidance of cracking in welds	5	Identify the metallurgical mechanisms for each of the major types of cracking. Describe the effects of chemical and physical variables for each of the major types of cracking. Classify susceptibility to cracking by reference to the key welding parameters Recognise the type and cause of cracking from study of fractured material and its history.	Choose appropriate precautions to avoid cracking. Select alternatives that will reduce or eliminate the occurrence of lamellar tearing in welded construction/fabrication.	Evaluate a welded joint and, under limited guidance, select options that may be applied to control the welding variables to avoid cracking	8
IWP	Apply basic knowledge on the fundamentals of various cracking mechanisms in welded joints, the way in which welding variables affect the incidence of cracking, and methods of avoidance.	Demonstrate fundamental knowledge and skills in methods of avoiding cracking phenomena applied to welded joints.	**4**	Identify the type of cracking and the reason for its occurrence. Outline the metallurgical mechanisms for each of the major types of cracking. List the most common cracking phenomena in welding joints: cold cracking, hot cracking, reheat cracking and lamellar tearing.	Select alternative solutions and appropriate precautions to avoid cracking. Select simple alternatives that will reduce or eliminate the occurrence of cold cracking, hot cracking, reheat cracking and lamellar tearing in welded fabrication. Determine the main factors affecting each cracking type. Choose the main tools to avoid cracking.	Appraise with limited autonomy the main factor affecting cracking when welding. Apply with limited autonomy basic procedures to eliminate cracking phenomena.	**6**

2.7 Fractures and different kinds of fractures				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	2	1	0
Scope:	P1	P1	P1	-
Fractures because of mechanical overload (mechanism and avoidance)…	X	X	X	-
Fatigue fractures (mechanism and avoidance)……	X	X	X	-
Creep fractures (mechanism and avoidance)……	X	X	X	-
Brittle fractures, ductile fractures……	X	X	X	-
Samples for cases of damage……	X	X	-	-

2.7 Fractures and different kinds of fractures – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the metallurgical mechanisms of different kinds of fractures in base materials and weldments	Demonstrate highly specialised knowledge and skills in fractures	7	Explain in detail the differences between cracks and fractures. Compare in detail ductile and brittle fractures Compare in detail the formation mechanisms of different types of fractures	Determine the fracture type from fracture surface information	Apply calculations and Failure Assessment Diagrams (FADs) to a fracture case study to determine the condition of the weld and identify the causes	8
IWT	Apply advanced understanding of the metallurgical mechanisms of different kinds of fractures in base materials and weldments	Demonstrate advanced knowledge and skills in fractures	6	Explain the differences between cracks and fractures Compare ductile and brittle fractures Compare the formation mechanisms of different types of fractures	Assess fracture types given fracture surface information	Apply Failure Assessment Diagrams (FADs) to a fracture case study, identify the type of fracture and predict its likely cause	4
IWS	Apply understanding of the metallurgical mechanisms of different kinds of fractures in base materials and weldments	Demonstrate specialised knowledge and skills in fractures	5	Describe the differences between cracks and fractures Recognise the differences between ductile and brittle fractures	Categorise fractures given fracture surface information	Identify the type of fracture in a given case study and, under limited guidance, select the possibe causes.	2
IWP	NOT APPLICABLE						

2.8 Heat treatment of base materials and welded joints				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	2	1
Scope:	P1	P1	P1	P1
Heat treatment of base materials				
Normalising……....	X	X	X	X
Hardening……..	X	X	X	-
Quenching and Tempering……	X	X	X	X
Solution annealing……..……..……	X	X	X	-
Homogenisation.....	X	X	X	X
Recrystallisation annealing……..……...	X	X	X	X
Precipitation hardening.....	X	X	X	-
Heat treatment of welded joints and work pieces				
Post Weld Heat Treatment (Stress relieving, normalizing, hardening).....	X	X	X	X
Technical guidelines for heat treatment				
Heat treatment procedures……..……...……..……..	X	X	X	X
Introduction to heat treatment equipment…….....	X	X	X	X
Regulations/guidelines (codes and technical reports) ISO/TR 17663….....	X	X	X	-
Introduction to temperature measurement and recording ISO 13916……....	X	X	X	X

2.8 Heat treatment of base materials and welded joints – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the metallurgical transformations of materials during different heat treatment	Demonstrate advanced knowledge and skills in the metallurgy of heat treatment of base materials and welded joints	6	Explain each of the major heat treatments and their objectives Compare the mechanisms of structural changes which take place when a material is heat treated. Compare the effects of temperature and time on transformations including the effect of temperature change rate. Interpret the code requirements for heat treatment Infer the purpose of the code requirements in terms of structural changes.	Predict the necessity to perform heat treatment after welding depending of the type and thickness of steel, the application and the code. Predict the mechanical property outputs in consideration of hardenability, mass effects and ruling sections.	Appraise furnace search data and interpret thermal charts to recommend heat treatment of a welded joint to achieve given requirements	8

IWS	Apply understanding of the metallurgical transformations of materials during different heat treatment	Demonstrate specialised knowledge and skills in the metallurgy of heat treatment of base materials and welded joints	4	Identify the major heat treatments and their objectives. Associate code requirements for heat treatment with their objectives	Choose appropriate heat treatment after welding depending of the type and thickness of steel, the application and the code.	Select and implement an appropriate heat treatment procedure for a given requirement	4
IWP	Apply basic knowledge about the metallurgical transformations of materials during different heat treatment.	Demonstrate fundamental knowledge and skills in metallurgical transformation of base materials and welded joints, when heat treated	4	Outline the major heat treatments and their objectives List the most common heat treatments of base materials and of welded joints List the necessary conditions/requirements when is needed to perform heat treatment after welding depending of the type and thickness of steel, the application and the product standards and/or construction codes and the code.	Measure and record of the temperature when welding: pre-heat and interpass temperatures.	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance pointing out how temperature will be measured. Control with limited autonomy if it will be need an heat treatment to the weld joints or not.	**2**

2.9 Structural (unalloyed) steels

Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	2	2
Scope:	P1	P1	P1	P1
Steels group 1 according to ISO/TR 15608	X	X	X	X
Chemical composition	X	X	X	X
Grades of unalloyed steels	X	X	X	X
Carbon equivalent CE	X	X	X	X
Relationship CE – hardenability	X	X	X	X
Welding processes	X	X	X	X
Filer materials, choice, standards	X	X	X	X
HAZ microstructure and properties (hardness, toughness)	X	X	-	-
Effects of weld heat treatment	X	X	X	X
Applications	X	X	-	-
Standards, (ISO, CEN and National)	X	X	X	X

2.9 Structural (unalloyed) steels – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply highly specialised understanding of structural unalloyed steels	Demonstrate highly specialised knowledge and	7	Compare the structural properties of unalloyed steels	Discuss the choice of welding process and filler material		8

	and the effects of welding processes on the weld joint	skills in welding of structural unalloyed steels		Relate standards for filler materials to weld properties based on chemistry and welding process used	given unalloyed steel grade and relevant standards Predict the effect of welding process and filler metal selection on weld HAZ properties		
IWS & IWP	Apply basic knowledge of structural unalloyed steels and the effects of welding processes on the weld joint	Demonstrate fundamental knowledge and skills in the application of structural unalloyed steels and in welding of structural unalloyed steels	4	Outline the most common structural properties of unalloyed steels Identify appropriate welding processes and filler materials. Recall the main grades and properties of structural steels. (Unalloyed or low alloyed steels).	Choose the appropriate welding processes and filler materials for a given application. Make use of the appropriate application of ISO, CEN and National standards for filler materials.	Appraise with limited autonomy the application of appropriate welding process.	4

2.10 High strength steels				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	10	8	4	1
Scope:	P3	P3	P3	P3
Steels group 2 and 3 according to ISO/TR 15608	X	X	X	X
Concept of grain refinement (micro-alloying elements, formation and dilution of particles)	X	X	-	-
Principles of treatment (controlled rolling, accelerated cooling, direct quench, thermomechanical treatment etc.)	X	X	X	X
Normalised grades (Chemical composition, properties)	X	X	X	X
Quenched and tempered grades (Chemical composition, properties)	X	X	X	X
High strength steels (Chemical composition, Mechanical properties)	X	X	X	X
Weldability, $t_{8/5}$ concept, preheat and interpass temperature, CE	X	X	-	-
Influence of welding process on HAZ (microstructure, properties)	X	X	-	-
Steels for automotive industries (TRIP, TWIP, dual phase, etc.)	X	X	-	-
Applications	X	X	X	X
Standards global (ISO), regional (CEN) and National	X	X	X	X
Choice of filler metal (mismatching, etc.)	X	X	X	-

2.10 High strength steels – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**

IWE	Apply highly specialised understanding of the effects of micro-alloying elements on structure, mechanical properties and weldability, with reference to fine-grained and high strength steels	Demonstrate highly specialised knowledge and skills in the properties of high strength steels	7	Explain in detail the different methods to obtain fine-grained steels, including the effects of micro-alloying. Relate grain refinement to mechanical properties. Relate steel grade to weldability Compare applicable welding processes Explain in detail the effects of heat treatment after welding and contrast applicable welding processes and their effect on metallurgical response	Discuss appropriate applications of high strength steels Predict potential problems for given welding processes and steel grades Justify the selection of heat treatment conditions (in particular temperature) for given welding processes and steel grades Decide on the appropriate filler metal for a given application		20
IWT	Apply advanced understanding of the effects of micro-alloying elements on structure, mechanical properties and weldability, with reference to fine-grained and high strength steels	Demonstrate advanced knowledge and skills in the properties of high strength steels	6	Explain in detail the different methods to obtain fine-grained steels, including the effects of micro-alloying. Compare the mechanical properties achieved through grain refinement Interpret the relationship between grade and weldability Compare applicable welding processes Explain the effects of heat treatment after welding	Select appropriate applications of high strength steels Predict potential problems for given welding processes and steel grades Select heat treatment conditions (in particular temperature) for given welding processes and steel grades Select the appropriate filler metal for a given application		16
IWS	Apply understanding of the effects of micro-alloying elements on structure, mechanical properties and weldability, with reference to fine-grained and high strength steels	Demonstrate specialised knowledge and skills in the properties of high strength steels	5	Describe the different methods to obtain fine-grained steels Associate grain refinement with mechanical properties. Recognise the relationship between grade and weldability Identify applicable welding processes Associate specific welding processes with potential problems Recognise the effects of heat treatment after welding	Select appropriate applications of high strength steels Select heat treatment conditions (in particular temperature) for given welding processes and steel grades Choose the appropriate filler metal for a given application		4
IWP	Apply basic knowledge about the effects of micro-alloying elements on structure, mechani-	Demonstrate fundamental knowledge and skills in determining the effects of micro alloying to high	4	Outline the relationship between grain refinement and mechanical properties. Outline the relationship between grade and weldability.	Choose the appropriate welding processes and filler materials for a given application	Appraise with limited autonomy the application of appropriate welding process according to each fine-grain	**2**

	cal properties and weldability with reference to fine-grained and high strength steels.	strength steels regarding these steels weldability.		Identify the most common applicable welding processes and potential problems.	Determine the main effects of heat treatment after welding, deducing the conditions of such treatment.	steel material and how to minimise .	

2.11 Application of structural and high strength steels				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	2	2	2	1
Scope:	P3	P3	P3	P3
Bridges ……..	X	X	X	X
Cranes ……	X	X	X	X
Buildings ……	X	X	X	X
Ships……..	X	X	X	X
Pipeliness ……	X	X	X	X
Pressure vessels ……..……..	X	X	X	X
Automotive equipment ……	X	X	X	X
Standards global (ISO), regional (CEN) and National ……..……	X	X	X	X

2.11 Application of structural and high strength steels – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply highly specialised understanding of welding problems dealing with the fundamental aspects of the application of structural and high strength steels, with particular reference to physical, chemical and mechanical characteristics.	Demonstrate highly specialised knowledge and skills in application of structural and high strength steels	7	Explain in detail the importance of choice of material with reference to specific applications Explain in detail the use of structural and high strength steels and their application fields	Discuss the practical application of high strength steels in the designs of bridges, cranes, pressure vessels, automotive equipment, buildings (architectures), ships, and pipelines etc.	Appraise a given welded fabrication study and recommend the material, welding process and welding consumable selection to achieve the required characteristics, providing alternatives where relevant	4
IWS	Apply understanding of welding problems dealing with the fundamental aspects of the application of structural and high strength steels, with particular reference to physical, chemical and mechanical characteristics.	Demonstrate specialised knowledge and skills in application of structural and high strength steels	5	Recognise the importance of choice of material with reference to application Describe the use of structural and high strength steels and their application fields.	Show, using examples, the practical application of high strength steels in designs of bridges, cranes, pressure vessels, automotive equipment, buildings (architectures), ships, and pipelines etc.	Evaluate a given welded fabrication study and, under limited guidance, select the welding methods and control conditions in the use of structural and high-strength steel	4

IWP	Apply basic knowledge about welding problems dealing with the fundamental aspects of the application of structural and high strength steels, with particular reference to physical, chemical and mechanical characteristics.	Demonstrate fundamental knowledge and skills in the application of structural and high strength steels	4	Recognise the importance of choice of material with reference to application Outline the most common application of structural and high strength steels.	Illustrate with examples the use of structural and high strength steels, outlining their application fields Illustrate with examples of the practical application and design of bridges, cranes, pressure vessels, automotive equipment.	Appraise with limited autonomy the application of appropriate welding process according to each material.	**2**

2.12 Creep and creep resistant steels				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	3	2	0
Scope:	P3	P3	P3	-
Creep mechanism	X	X	X	-
Creep sensitivity testing	X	X	X	-
Temper embrittlement, e.g. step cooling test	X	X	X	-
Types of creep/heat resistant steels ISO/TR 15608, groups 4, 5, and 6.....	X	X	X	-
Applicable welding processes	X	X	X	-
Filler materials - special chemical requirements for creep resistance	X	X	X	-
Welding problems and precautions	X	X	X	-
Effects of weld heat treatment.....	X	X	X	-
Quality control of the welded joint	X	X	X	-
Standards (ISO, CEN and National).....	X	X	X	-

2.12 Creep and creep resistant steels – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of creep phenomena, general creep-resistant steel types, their structure and alloying elements	Demonstrate highly specialised knowledge and skills in creep and creep-resistant steels	7	Explain in detail the fundamental aspects of the phenomena and phases of creep Relate the effects of alloying elements and steel structure to creep resistance	Discuss the weldability of Cr-Mo steels considering appropriate welding processes and types of consumables Predict remaining creep life by use of the most common methods.		8

IWT	Apply advanced understanding of creep phenomena, general creep-resistant steel types, their structure and alloying elements	Demonstrate advanced knowledge and skills in creep and creep-resistant steels	6	Explain the fundamental aspects of the phenomena and phases of creep Compare the effects of alloying elements and steel structure on creep resistance	Assess the weldability of Cr-Mo steels considering appropriate welding processes and types of consumables. Predict remaining creep life by use of the most common methods.		6
IWS	Apply understanding of creep phenomena, general creep-resistant steel types, their structure and alloying elements	Demonstrate specialised knowledge and skills in creep and creep-resistant steels	5	Describe the fundamental aspects of the phenomena and phases of creep Recognise the effects of alloying elements and steel structure on creep resistance	Categorise the weldability of Cr-Mo steels considering appropriate welding processes and types of consumables.		4
IWP	NOT APPLICABÇLE						

2.13 Steels for cryogenic applications

Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	3	2	0
Scope:	P3	P3	P3	-
Steels group 9 according to ISO/TR 15608	X	X	X	-
Requirements for low temperature applications	X	X	X	-
Survey/list of cryogenic steels (including 9% Ni)	X	X	X	-
Effects of nickel on low temperature properties of low alloy steels	X	X	X	-
Applicable welding processes	X	X	X	-
Filler materials	X	X	X	-
Welding problems and precautions	X	X	X	-
Properties and application of various types of cryogenic steels	X	X	-	-
Quality control of the welded joint	X	X	X	-
Standards (ISO, CEN and National)	X	X	X	-

2.13 Steels for cryogenic applications – LEARNING OUTCOMES

	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of solutions to welding applications requiring the use of	Demonstrate highly specialised knowledge and skills in application of	7	Explain in detail methods of toughness testing and the parameters affecting toughness	Discuss the range of applications for the various types of cryogenic steels		8

	the relationship between toughness and temperature, metallurgical structure and the weldability of cryogenic steels	welding to cryogenic steels		Relate microstructure to toughness of cryogenic steels Exemplify the effect of nickel on crystallographic structure Exemplify the effect of nickel content on weldability	Predict weldability of cryogenic steels, considering appropriate welding processes and types of consumables		
IWT	Apply advanced understanding of solutions to welding applications requiring the use of the relationship between toughness and temperature, metallurgical structure and the weldability of cryogenic steels	Demonstrate advanced knowledge and skills in application of welding to cryogenic steels	6	Explain methods of toughness testing and the parameters affecting toughness Explain the effect of nickel on crystallographic structure Compare the effect of differing levels of nickel content on weldability of cryogenic steels	Discuss the range of applications for the various types of cryogenic steels Assess weldability of cryogenic steels, considering appropriate welding processes and types of consumables		6
IWS	Apply understanding of solutions to welding applications requiring the use of the relationship between toughness and temperature, metallurgical structure and the weldability of cryogenic steels	Demonstrate specialised knowledge and skills in application of welding to cryogenic steels	5	Recognise the effect of nickel on crystallographic structure Associate weldability of cryogenic steels with the effect of nickel content	Show the range of applications for the various types of cryogenic steels Categorise the weldability of cryogenic steels, considering appropriate welding processes and types of consumables		4
IWP	NOT APPLICABLE						

2.14 Introduction to corrosion				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	3	2	1
Scope:	P3	P3	P3	P3
Fundamentals of electrochemistry ……	X	X	X	-
Redox potential ……	X	X	X	-
Passivation ……	X	X	X	X
Overall corrosion ……	X	X	X	X
Differential aeration ……	X	X	X	
Cathodic, anodic protection ……	X	X	X	-
Types of corrosion (intercrystalline, transcrystalline, knife-line attack. pitting, crevice, and stress-corrosion) ……	X	X	X	-
Pickling and passivating.....	X	X	X	X
Corrosion testing ……	X	X	X	-
Demonstrations for IWE - 2 hours from 4				
Demonstrations for IWT - 1 hour from 3				
Demonstrations for IWS/IWP - 0 hours				

2.14 Introduction to corrosion – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the fundamentals of the various types of corrosion	Demonstrate highly specialised knowledge and skills in the fundamentals of corrosion	7	Explain in detail the chemical and electrochemical phenomena involved in corrosion Compare the mechanisms of the different types of corrosion Explain how welding of dissimilar metals, and formation of carbides and intermetallic compounds during welding creates electrode potentials that may cause corrosion coupling (galvanic cells)	Discuss different corrosion protection methods		8
IWT	Apply advanced understanding of the fundamentals of the various types of corrosion	Demonstrate advanced knowledge and skills in the fundamentals of corrosion	6	Explain the chemical and electrochemical phenomena involved in corrosion Compare the mechanisms of the different types of corrosion	Select corrosion protection methods.		6
IWS	Apply understanding of the fundamentals of the various types of corrosion	Demonstrate specialised knowledge and skills in the fundamentals of corrosion	5	Describe the chemical and electrochemical phenomena involved in corrosion Classify the most common types of corrosion	Show examples of common corrosion protection methods		4

IWP	Apply basic knowledge of the fundamentals of the various types of corrosion.	Demonstrate fundamental knowledge and skills in recognising the corrosion types and in identifying possible protection methods.	4	Identify the major distinctive characteristics of the different types of corrosion. List the most common factors that can affect passive layers. Outline the most common methods to avoid pickling.	Illustrate with proper examples the common protection methods.	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance pointing out the most common methods to prevent corrosion.	3

2.15 Stainless and heat resistant steels				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	12	9	5	2
Scope:	P3	P3	P3	P3
Effect of alloying elements on binary diagrams and phase composition.....	X	X	X	X
Systems Fe-Cr, Fe-Ni, Fe-Cr-Ni ……..……...……	X	X	-	-
Austenite and ferrite formers ……..	X	X	X	X
Influence of nitrogen ……..……..……	X	X	X	X
Cr- and Ni-equivalent ……..	X	X	X	-
Schaeffler diagram, DeLong and other constitution diagrams ……..……	X	X	X	-
Measuring of ferrite content (ISO 8249, ISO 17655)……..……..……	X	X	-	-
t $_{12/8}$ weldability concept…….....	X	X	-	-
Survey on stainless steels (fully austenitic, ferrite-containing steels, ferritic, martensitic, precipitation hardened, duplex stainless steels, chemically resistant, creep resistant, heat resistant steels, superferritic, supermartensitic and superaustenitic stainless steel e.g. duplex and lean duplex stainless steel) ISO/TR 15608, groups 7, 8, 9 and 10.....	X	X	X	X
Welding of stainless steels ……..……..……	X	X	X	X
Applicable welding processes ……..……	X	X	X	X
Weldability and selection of consumables ……...	X	X	X	X
Choice of filler materials ……..……...	X	X	X	X
Shielding and backing gases ……..……..……	X	X	X	X
Details of joint design ……..……....	X	X	X	X
Heat treatment ……..……..……	X	X	X	X
Post-weld heat treatment (PWHT) ……..……...	X	X	X	X
Passivation ……..……	X	X	X	X
Knife-line attack ……..……	X	X	-	-
475 °C-embrittlement..……	X	X	-	-
Weld decay (intergranular corrosion) ……..……..	X	X	-	-
Pitting Index ……..……..……..	X	X	X	-

Mechanism of heat resistance ……..	X	X	X	X
Oxidation resistance ……	X	X	X	X
Standards (ISO, CEN and National).....	X	X	X	X

2.15 Stainless and heat resistant steels – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the fundamentals of the various types of stainless and heat resistant steels and their weldability, including filler metal choice	Demonstrate highly specialised knowledge and skills in the weldability of stainless and heat resistant steels	7	Explain in detail the structures of the various stainless steels; parent metal, HAZ and weld metal Infer the structure of a given high alloy weld from the Fe-Cr-Ni phase diagram Exemplify the rules and principles governing embrittlement phenomena Exemplify the rules and principles governing in detail corrosion phenomena Infer the structure of a given high alloy welding situation using the Fe-Cr-Ni phase diagram with various carbon contents Relate the effects of alloying elements to heat resistance Explain in detail the microstructural phenomena occurring in materials at high temperature Compare the properties of creep resistant and heat resistant steels. Explain in detail the weldability of creep and heat resistant steels.	Decide on the choice of welding process and consumables for each type of stainless steel using different diagrams Predict the necessity for treatment after welding for given materials, consumables and welding processes	Appraise a case study and demonstrate which filler metals and process controls are required to prevent embrittlement and solidification cracking of welded stainless and heat resistant steels.	24
IWT	Apply advanced understanding of the fundamentals of the various types of stainless and heat resistant steels and their weldability, including filler metal choice	Demonstrate advanced knowledge and skills in the weldability of stainless and heat resistant steels	6	Explain the structures of the various stainless steels; parent metal, HAZ and weld metal Interpret the Fe-Cr-Ni phase diagram for a given high alloy weld Explain the rules and principles governing embrittlement phenomena	Select the welding process and consumables for each type of stainless steel using different diagrams Select the treatment after welding for given materials, consumables and welding processes	Appraise a case study and select appropriate filler metals and process controls that are required to prevent embrittlement and solidification crack-	18

				Explain the rules and principles governing in detail corrosion phenomena Interpret the Fe-Cr-Ni phase diagram for given high alloy welds with various carbon contents Compare heat resistance relative to the effects of alloying elements Explain the microstructural phenomena occurring in materials at high temperature Compare the properties of creep resistant and heat resistant steels. Explain the weldability of creep and heat resistant steels.		ing of welded stainless and heat resistant steels.	
IWS	Apply understanding of the fundamentals of the various types of stainless and heat resistant steels and their weldability, including filler metal choice	Demonstrate specialised knowledge and skills in the weldability of stainless and heat resistant steels	5	Identify the structures of the various stainless steels Associate the various stainless steels with their behaviour during welding Describe the rules and principles governing corrosion phenomena Recognise the necessity of treatment after welding Describe the different treatments after welding.	Select the welding process and consumables for each type of stainless steel using different diagrams	Evaluate a case study and, under limited guidance, select apropriate filler metals and process controls that are required to achieve requirements for welded stainless and heat resistant steels.	10
IWP	Apply basic knowledge on fundamentals of the various types of stainless and heat resistance steels and their weldability including the filler material choice.	Demonstrate fundamental knowledge and skills in the weldability of stainless and heat resistance steels.	4	Outline the structures of the various stainless steels. Outline the most common welding processes and consumables for each type of steel. Identify the main different treatments after welding. Interpret the appropriate ISO, CEN and National standards applied to Stainless and heat resistant steels. Compare the different types of stainless steel.		Appraise with limited autonomy the application of appropriate welding process according to each material.	6

2.16 Introduction to wear and protective layers				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	5	3	2	0
Scope:	P3	P3	P3	-
Wear:				
Different types of wear (hydrodynamic friction, reaction, layer wear, adhesive wear, abrasive wear, fatigue wear, fretting, erosion, cavitation, impact, thermal, dynamic) ……..	X	X	X	-
Buttering ……..	X	X	-	-
Wear tests ……..	X	X	-	-
Cladding:				
Cladding layers and cladding processes (dilution)	X	X	X	-
Joining clad steels ……	X	X	X	-
Joint design and welding procedures in respect to the access to the joint...	X	X	-	-
Applications ……..	X	X	X	-
Standards ……...	X	X	X	-
Linings:				
Welding of linings ……..	X	X	X	-
Joint design and welding procedures …….....	X	X	X	-
Surfacing:				
Corrosion-resistant layers ……...	X	X	X	-
Wear-resistant layers ……	X	X	X	-
Coatings:				
Coated steels	X	X	X	-
Galvanised steels (Si-content) ……...	X	X	X	-
Painting ……..	X	X	X	-
Problems of joining ……...	X	X	-	-

2.16 Introduction to wear and protective layers – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the fundamentals of wear and protective layers and the methods and materials used	Demonstrate highly specialised knowledge and skills in the fundamentals of wear and protective layers	7	Exemplify in detail wear situations involving each of the mechanisms for the different types of wear Compare the methods and results of tests to define wear resistance Explain in detail the precautions and procedures designed to avoid excessive wear	Produce weldment designs with protective layers Justify the selection of materials used in weldment design with protective layers	Appraise a case study and recommend protective layer solutions to achieve requirements, providing alternatives where appropriate	10

				Compare in detail the various techniques for applying protective layers	Predict the potential problems associated with different types of protective layer Discuss methods of resolving problems with different types of protective layer		
IWT	Apply advanced understanding of the fundamentals of wear and protective layers and the methods and materials used	Demonstrate advanced knowledge and skills in the fundamentals of wear and protective layers	6	Exemplify wear situations involving each of the mechanisms for the different types of wear Compare the methods and results of tests to define wear resistance Interpret the precautions and procedures designed to avoid excessive wear Compare the various techniques for applying protective layers Explain methods of resolving problems with different types of protective layer	Assess the selection of materials used in weldment design with protective layers Predict the potential problems associated with different types of protective layer	Appraise a case study and select protective layer solutions to achieve requirements, identifying suitable alternatives where appropriate	6
IWS	Apply understanding of the fundamentals of wear and protective layers and the methods and materials used	Demonstrate specialised knowledge and skills in the fundamentals of wear and protective layers	4	Identify wear situations that involve the mechanisms of the different types of wear Associate the results of tests with wear resistance Describe precautions and procedures designed to avoid excessive wear Recognise the advantages and disadvantages of the various techniques for applying protective layers	Categorise the problems associated with each method of applying protective layers Choose solutions for problems with protective layers	Evaluate a case study and, under limited guidance,select protective layer solutions to achieve requirements	4
IWP	NOT APPLICABLE						

2.17 Cast irons and steels				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	2	2	2	0
Scope:	P3	P3	P3	-
Cast iron and cast steels – definition and classification ISO/TR 15608.....	X	X	X	-
Survey of cast steels ……	X	X	X	-
Survey of cast irons ……	X	X	X	-
Weldability of cast iron and cast steels.....	X	X	X	-
Applicable welding processes and procedures ……....	X	X	X	-
Filler materials …….....	X	X	X	-
Application and special welding problems …….....	X	X	X	-
Standards (ISO, CEN and National).....	X	X	X	-

2.17 Cast irons and steels – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply highly specialised understanding of the metallurgy of the different types of cast irons and steels, their application fields and weldability	Demonstrate highly specialised knowledge and skills in the weldability of cast irons and steels	6	Explain in detail the Fe - C phase diagram with particular attention to carbon content over 2% Compare the different types of cast irons and steels, their chemical composition and crystallographic structures	Discuss the weldability problems and applicable welding processes and types of consumable for the welding of cast irons.	Appraise a case study and recommend consumable types, preparation methods and thermal management procedures to minimise hardness and prevent cracking for different types of cast iron and cast steel	4
IWS	Apply understanding of the metallurgy of the different types of cast irons and steels, their application fields and weldability	Demonstrate specialised knowledge and skills in the weldability of cast irons and steels	5	Classify the different types of cast irons and steels	Categorise the weldability problems for given welding processes, consumables and types of cast irons and steels	Evaluate a case study and, under limited guidance, select recommend consumable types, preparation methods and welding controls that will improve the weldability of given types of cast iron and cast steel	4
IWP	NOT APPLICAVBLE						

2.18 Copper and copper alloys				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	2	2	1	0
Scope:	P3	P3	P3	-
Classification of copper and copper alloys ISO/TR 15608.....	X	X	X	-
Physical and mechanical properties ……	X	X	X	-
Deoxidation and weldability ……	X	X	X	-
Applicable joining processes (welding, brazing, soldering, diffusion bonding).....	X	X	X	-
Filler materials ……	X	X	X	-
Shielding and backing gases ……	X	X	X	-
Application and special problems ……	X	X	X	-
Standards (ISO, CEN and National) ……	X	X	X	-
Quality control of the welded joint ……	X	X	X	-

2.18 Copper and copper alloys – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the metallurgy and the range of application and weldability of copper and copper alloys	Demonstrate advanced knowledge and skills in the metallurgy and weldability of copper and coper alloys	6	Explain the metallurgy of copper and copper alloys Interpret the weldability of given copper and copper alloys, including dissimilar joints Exemplify the range of application for copper and copper alloys.	Discuss applicable welding processes and types of consumable for copper and copper alloys	Appraise a case study and recommend the necessary heat inputs filler materials and shielding gases to achieve quality requirements in copper and copper alloy for a selection of joining processes	4
IWS	Apply understanding of the metallurgy and the range of application and weldability of copper and copper alloys	Demonstrate specialised knowledge and skills in the metallurgy and weldability of copper and coper alloys joints	5	Classify copper and copper alloy weldability Associate copper and copper alloys with specific applications	Select applicable welding processes and types of consumable for copper and copper alloys.	Evaluate a case study and, under limited guidance, select appropriate filler material and shielding gas to achieve quality requirements in copper and copper alloy for a given joining process.	2
IWP	NOT APPLICABLE						

2.19 Nickel and nickel alloys				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	2	1	1	0
Scope:	P3	P3	P3	-
Classification of nickel and nickel alloys ISO/TR 15608.....	X	X	X	-
Weldability of nickel and nickel alloys …….....	X	X	X	-
Applicable welding processes and filler materials …….....	X	X	X	-
Shielding and backing gases ……..	X	X	X	-
Welding problems (hot cracking) and prevention ……..……	X	X	X	-
Quality control of the welded joint ……..……	X	X	X	-
Application and special problems ……..	X	X	X	-
Standards (ISO, CEN and National) ……..	X	X	X	-

2.19 Nickel and nickel alloys – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the metallurgy, the range of application and the weldability of nickel and nickel alloys	Demonstrate highly specialised knowledge and skills in the metallurgy and weldability of nickel and nickel alloys	7	Explain in detail the metallurgy of nickel and nickel alloys Interpret the weldability of various nickel and nickel alloy materials Exemplify nickel and nickel alloys applications	Discuss applicable welding processes and types of consumable for nickel and nickel alloys	Appraise a case study and recommend the process, consumable type, preparation method and shielding gas to avoid hot cracking and solid-state microcracks in welding of various nickel and nickel alloys, providing alternatives where necessary	4
IWT	Apply advanced understanding of the metallurgy, the range of application and the weldability of nickel and nickel alloys	Demonstrate advanced knowledge and skills in the metallurgy and weldability of nickel and nickel alloys	6	Explain nickel and nickel alloy weldability Compare examples of nickel and nickel alloys applications	Select applicable welding processes and types of consumable for nickel and nickel alloys	Appraise a case study and select the process, consumable type, preparation method and shielding gas to achieve quality requirements for selected nickel alloys in a given application	2
IWS	Apply understanding of the metallurgy, the range of application and the weldability of nickel and nickel alloys	Demonstrate specialised knowledge and skills in the metallurgy and weldability of nickel and nickel alloys	5	Classify nickel and nickel alloy weldability Recognise examples of nickel and nickel alloys applications	Select applicable welding processes and types of consumable for nickel and nickel alloys.	Evaluate a case study and, under limited guidance, select the process, consumable type, preparation method and shielding gas to achieve quality requirements for a given nickel alloy in a given application	2
IWP	NOT APPLICABLE						

2.20 Aluminium and aluminium alloys				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	6	4	2	2
Scope:	P3	P3	P3	P3
Classification of Al and Al-alloys (pure, cold work alloys, heat treatable) ISO/TR 15608	X	X	X	X
Weldability of Al and Al-alloys (HAZ softening, porosity and hot cracking, cracking diagrams, distortion)	X	X	X	X
Oxide layer cleaning (cathodic cleaning, trailing and trailing shield)	X	X	X	X
Applicable welding processes	X	X	X	X
Filler materials (choice, storage and handling)	X	X	X	X
Shielding and backing gases	X	X	X	X
Design details	X	X	X	X
Joint preparation	X	X	X	X
Application and special problems (lightweight structures, cryogenic use)	X	X	X	X

2.20 Aluminium and aluminium alloys – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the metallurgy, the range of application and the weldability of nickel and nickel alloys	Demonstrate highly specialised knowledge and skills in the metallurgy and weldability of nickel and nickel alloys	7	Explain in detail the metallurgy of aluminium and aluminium alloys Interpret the weldability of various aluminium and aluminium alloys, including dissimilar joints Exemplify aluminium and aluminium alloy application	Discuss applicable welding processes and types of consumable for aluminium and aluminium alloys.	Appraise a case study and recommend the process, consumable type, preparation method and shielding gas to avoid hot cracking and solid-state microcracks in welding of various aluminium alloys, providing alternatives where necessary	12
IWT	Apply advanced understanding of the metallurgy, the range of application and the weldability of nickel and nickel alloys	Demonstrate advanced knowledge and skills in the metallurgy and weldability of nickel and nickel alloys	6	Explain aluminium and aluminium alloy weldability including dissimilar joints Compare examples of aluminium and aluminium alloy applications	Select applicable welding processes and types of consumable for aluminium and aluminium alloys	Appraise a case study and select the process, consumable type, preparation method and shielding gas to achieve quality requirements for selected aluminium alloys in a given application	8
IWS & IWP	Apply basic knowledge of the metallurgy, the range of application and the weldability of aluminium and aluminium alloys.	Demonstrate fundamental knowledge and skills in the metallurgy and weldability of nickel and nickel alloys	4	Classify aluminium and aluminium alloy weldability Recognise examples of aluminium and aluminium alloy applications	Select applicable welding processes and types of consumable for aluminium and aluminium alloys.	Give assistance to the identification, storage and handling of consumables. Give assistance to the application of welding processes for Al and Al-alloys	4

2.21 Titanium and other metals and alloys				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	3	2	1	0
Scope:	P3	P3	P3	-
Titanium, Classification according to ISO/TR 15608.....	X	X	X	-
Magnesium. Classification according to ISO/TR 15608.....	X	X	X	-
Tantalum….....	X	-	-	-
Zirconium ……....	X	-	-	-
Applicable welding processes and filler materials ……...	X	X	X	-
Special problems ……..	X	X	-	-

2.21 Titanium and other metals and alloys – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the metallurgy, application fields and weldability of titanium, magnesium, tantalum and zirconium	Demonstrate highly specialised knowledge and skills in the metallurgy and weldability of titanium and other special metals and alloys	7	Explain in detail the metallurgy of the specified metals and alloys Interpret the weldability of these metals	Discuss appropriate welding processes, consumables and applications for given metals and alloys	Appraise a case study and recommend the process and consumable type to achieve weld quality requirements for various applications of titanium and other special metals and alloys	6
IWT	Apply advanced understanding of the metallurgy, application fields and weldability of titanium, magnesium, tantalum and zirconium	Demonstrate advanced knowledge and skills in the metallurgy and weldability of titanium and other special metals and alloys	6	Explain the metallurgy of the specified metals and alloys Compare the weldability of the specified metals	Select appropriate welding processes, consumables and applications for given metals and alloys	Appraise a case study and select the process and consumable type to achieve quality requirements for selected special metals and alloys in a given application	4
IWS	Apply understanding of the metallurgy, application fields and weldability of titanium, magnesium, tantalum and zirconium	Demonstrate specialised knowledge and skills in the metallurgy and weldability of titanium and other special metals and alloys	5	Identify the welding metallurgy of the specified metals Classify the weldability of the specified metals	Select appropriate welding processes, consumables and applications for given metals and alloys	Evaluate a case study and, under limited guidance, select the process and consumable type to achieve quality requirements for a given special metals or alloy in a given application	2
IWP	NOT APPLICABLE						

2.22 Joining dissimilar materials				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	3	2	1
Scope:	P3	P3	P3	P3
Fundamentals of joining dissimilar materials…….....	X	X	X	X
Use of the Schaeffler / De Long / WRC diagram for welding dissimilar metals ……	X	X	X	-
Choice of processes ……	X	X	X	X
Effect of dilution, buttering……..……	X	X	X	X
Consumables ……	X	X	X	X
Welding problems and measures, (formation of intermetallic compounds, carbon migration) …….....	X	X	-	-
In service failures (thermal fatigue, disbonding) ……..	X	X	-	-
Typical applications:				
Joining high alloyed steel and mild steel ……..……..	X	X	X	X
Joining stainless steel and mild steel ……..……	X	X	X	X
Joining Austenitic stainless steel and martensitic stainless steel……..……	X	X	X	-
Joining Austenitic stainless steel and ferritic stainless steel……..……	X	X	X	-
Joining Austenitic stainless steel and duplex stainless steel ……..……	X	X	X	-
Joining Cu-Ni-alloys with mild steel/stainless steel ……	X	X	X	-
Joining Ni-alloys with mild steel ……...	X	X	X	-
Joining stainless steel and copper alloys ……..	X	X	X	-
Joining steel and Al / Al alloys ……	X	X	X	-
Joining Cu and Al / Al alloys ……	X	X	-	-
Joining Ni and Cu ……..	X	X	-	-

2.22 Joining dissimilar materials – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the principles of joining dissimilar materials and the problems involved	Demonstrate highly specialised knowledge and skills in joining dissimilar materials	7	Explain in detail the metallurgical and weldability aspects involved when joining dissimilar materials Infer welding metallurgical phases from Schaeffler / De Long /WRC diagram Consider the limitations of using Schaeffler / De Long /WRC diagrams	Discuss welding methods that can resolve metallurgical problems Justify the choice of filler material for dissimilar metal welds	Appraise a case study and recommend the process and consumable type to achieve weld quality requirements for various applications of dissimilar metal welds	8

IWT	Apply advanced understanding of the principles of joining dissimilar materials and the problems involved	Demonstrate advanced knowledge and skills in joining dissimilar materials	6	Explain the metallurgical and weldability aspects involved when joining dissimilar materials Interpret Schaeffler / De Long / WRC diagram	Select welding methods that can resolve metallurgical problems Select the correct filler material for dissimilar metal welds	Appraise a case study and select the process and consumable type to achieve quality requirements for selected dissimilar metal welds in a given application	6
IWS	Apply understanding of the principles of joining dissimilar materials and the problems involved	Demonstrate specialised knowledge and skills in joining dissimilar materials	5	Identify the weldability aspects involved when joining dissimilar materials Associate specific welding methods with reduction in metallurgical problems	Choose appropriate consumables based on given Schaeffler / De Long /WRC diagrams	Evaluate a case study and, under limited guidance, select the process and consumable type to achieve quality requirements for a given dissimilar metal weld in a given application	4
IWP	Apply basic knowledge about of the principles of joining dissimilar materials and the problems involved.	Demonstrate fundamental knowledge and skills in joining dissimilar materials	4	Outline the most common weldability aspects involved when joining dissimilar materials	Illustrate with examples welding methods that decrease metallurgical simple problems	Give assistance to the application of welding processes for dissimilar joining.	2

2.23 Destructive testing of materials and welded joints				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	14	14	8	3
Scope:	P3	P3	P3	P3
Destructive testing				
Tensile tests……..	X	X	X	X
Bend tests ……..	X	X	X	X
Impact tests ……..	X	X	X	X
Hardness tests…….....	X	X	X	X
Fatigue tests ……..	X	X	X	X
Fracture mechanics tests (CTOD, etc.) ……	X	X	X	-
Creep tests……	X	X	-	-
Corrosion tests……..…	X	X	-	-
Chemical analysis.....	X	X	-	-
Determination of hydrogen content.....	X	X	X	-
Metallographic examination of materials and their welded joint				
Preparation of specimens (grinding, polishing, etching).....	X	X	X	-
Equipment for preparation (manual, mechanical, automatic).....	X	X	X	-
Microscopes for examination (optical, electron).....	X	X	X	-
Microscopic and macroscopic examination of welds.....	X	X	X	X
Standards for testing .....……..……..…	X	X	X	-
Laboratory exercises for IWE / IWT - 6 hours from 14				
Laboratory exercises for IWS - 4 hours from 8				
Laboratory exercises for IWP - 1 hour from 3				

2.23 Destructive testing of materials and welded joints – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the fundamental aspects of testing materials with particular reference to welded test pieces	Demonstrate advanced knowledge and skills in destructive testing of materials and welded joints	6	Explain the purpose of destructive testing and the limitations of the data generated Compare the major testing methods and the parameters measured by each of them	Justify the need for special testing to be specified	Recommend special testing to achieve specified quality requirements Undertake destructive testing tasks in accordance with given schedules	28
IWS	Apply understanding of the fundamental as-	Demonstrate specialised knowledge and skills in	5	Identify the objectives of destructive testing and the limitations of the data generated	Show when and why special testing needs to be specified	Select appropriate special testing to achieve specified quality requirements	16

	pects of testing materials with particular reference to welded test pieces	destructive testing of materials and welded joints		Describe the major testing methods and the parameters measured by each of them		Undertake destructive testing tasks in accordance with given schedules	
IWP	Apply basic knowledge of the fundamental aspects of testing materials with reference to welded test pieces	Demonstrate fundamental knowledge and skills in reviewing destructive tests reports and be able to perform fracture tests.	4	Outline the most common reasons for destructive testing. List the major testing methods and the parameters to be measured.	Compare destructive testing, pointing out the common objectives and limitations of the data generated;	Review with limited autonomy tests reports and test results. Carry out with limited autonomy fracture tests.	6

Module 2 – Materials and their behaviour during welding

Module 2	IWE		IWT		IWS		IWP	
	MT	P1 *	MT	P1 *	MT	P1 *	MT	P1 *
Teaching Hours	115	33	96	31	56	16	23	10

***** P1 = Part 1, Figures under P1 are given for the Standard Route (see 4.1)

Module 3: Construction and design

Characterization of the general description of Module 3 – Construction and design, describing the Qualification descriptors in terms of Knowledge – K, Skills – S, Competences - C for each IIW welding coordination qualification

COMPETENCE UNIT 3: CONSTRUCTION AND DESIGN							
QUALIFICATION	**KNOWLEDGE**	**SKILLS**	**COMPETENCES**	**EQF LEVEL (EQF L)**	**TEACH-ING HOURS**	**WORKLOAD (WL)**	**ECVET POINTS**
INTERNATIONAL WELDING ENGINEER	*Highly specialized knowledge (able to deduce, detail and explain) and critical assessment of the theory, principals concerning the design and construction related to welding technology.*	*Highly specialized skills including critical evaluation (able to predict and deduce), to define/determine the best technical and economical solutions that shall be applied in terms of metal fabrication and design when applying welding technology in complex and unpredictable conditions.*	*Manage in detail the construction and design of welded products applications in a highly complex context.* *Act as the responsible person for the definition of the welding personnel tasks.*	7	62	124	15
INTERNATIONAL WELDING TECHNOLOGIST	*Advanced knowledge (able to deduce, detail and explain) and critical assessment of the theory, principals concerning the design and construction related to welding technology.*	*Advanced skills including critical evaluation (able to predict and deduce), to define/determine the best technical and economical solutions that shall be applied in terms of metal fabrication and design when applying welding technology in complex and unpredictable conditions.*	*Manage in detail the construction and design of welded products applications in a highly complex context.* *Act as the responsible person for the definition of the welding personnel tasks.*	6	44	88	10
INTERNATIONAL WELDING SPECIALIST	*Specialized and factual knowledge (able to understand and identify) of the theory and principles concerning the design and construction related to welding technology.*	*Specialised range of cognitive and practical skills which will allow choosing the proper technical and economical solutions in terms of metal fabrication and design when applying welding technology on common/regular problems.*	*Manage and supervise construction and design of welded products applications in unpredictable modifications.* *Act as the responsible person for supervise the welding personnel tasks.*	5	24	36	5
INTERNATIONAL WELDING PRACTITIONER	*Factual and theoretical knowledge (basic understand) of the theory and principles concerning the design and construction related to welding technology.*	*Range of cognitive and practical skills required to identify/choose the proper technical and economical solutions in terms of metal fabrication and design when applying welding technology on basic and specific problems.*	*Self-manage the construction and design of welded products applications usually predictable but subject to changes.* *Will act as the responsible person for supervise the welding personnel tasks.*	*4*	*6*	13	0,5

3.1 Basic theory of structural systems				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	2	0
Scope:	P1	P1	P3	-
Structural elements (cables, bars, beams, plates, slabs, shells) ……	X	X	X	-
Theory of forces ……	X	X	X	-
Combination and resolution of forces ……	X	X	X	-
Equilibrium of forces and torques ……	X	X	X	-
Bearings, constraints and basic types of connections ……	X	X	X	-
Equilibrium of structural systems ……	X	X	X	-
Statically determinate and indeterminate systems ……	X	X	X	-
Stress in structural systems resulting from external actions ……	X	X	X	-
Relationship between external loads and internal forces ……	X	X	-	-
Calculation and determination of the internal forces and moments of simple statically determinate systems.....	X	X	-	-

3.1 Basic theory of structural systems – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the effect of external loads on structures, the types of structural systems and the relationship between external loads and internal forces.	Demonstrate advanced knowledge and skills in explaining the conditions of equilibrium of structural systems and detailing the shearing force and bending moment of simple statically determinate systems	6	Explain in detail, the composition of forces, resolution of forces and the equilibrium conditions and the equilibrium of structural systems Explain in depth bearings, constraints and the basic types of connections Explain in depth the difference between a statically determinate and a statically indeterminate system	Calculate internal forces and moments of simple statically determinate systems Interpret, using sketches, the shearing force and bending moment diagram of simple statically determinate systems	Appraise, autonomously, a noncomplex structural system case study to verify if the design and calculations used are acceptable	8
IWS	Apply specialised understanding of the requirements and gain basic knowledge of the effect of external loads on structures, the types of structural systems and the relationship between external loads and internal forces	Demonstrate specialised knowledge and skills in point out the composition and resolution of forces, identifying the equilibrium in structural systems	5	Outline the composition and resolution of forces Outline the equilibrium of structural systems Identify the equilibrium conditions	Recognise bearings, constraints and the basic types of connections.	Evaluate a given basic structural system case study and, under limited guidance, recognise the safety factors	3
IWP	NOT APPLICABLE						

3.2 Fundamentals of the strength of materials				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	6	6	4	0
Scope:	P1	P1	P3	-
Types of stresses (normal stress, shear stress) ……	X	X	X	-
Types of deformation (axial strain, shear strain)……	X	X	X	-
Stress-strain relationship, yielding theories……	X	X	X	-
Elastic and plastic deformation ……	X	X	X	-
Young's modulus, shear modulus, transverse contraction coefficient …….	X	X	X	-
Characteristic material properties ……	X	X	X	-
Different stresses resulting from internal forces and moments……	X	X	X	-
Different types of section properties ……	X	X	X	-
Cross section variables ……	X	X	X	-
Calculation of stresses ……	X	X	-	-
Limit states of failures: ductile, brittle, fatigue, creep. ……	X	X	-	-

3.2 Fundamentals of the strength of materials – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the principles governing the behaviour of metallic structures under loading.	Demonstrate advanced knowledge and skills in explaining the stress-strain relationships and detailing the stresses resulting from internal forces and moments	6	Explain the different types of stresses and different types of deformation Explain the determination of characteristic material properties Detail the stresses resulting from internal forces and moments	Calculate the different types of cross section variables and nominal stresses in sections	Appraise, autonomously, a noncomplex structural system case study, to analyse its specific application and verify that the calculation methods and results are acceptable	12
IWS	Apply specialised understanding of the requirements and gain basic knowledge of the principles governing the behaviour of metallic structures under loading.	Demonstrate specialised knowledge and skills in outlining the different types of stresses and deformations in a metallic structure under a certain load	5	Outline different types of stresses and deformation Outline the stress-strain relationships	Identify the stresses resulting from internal forces and moments	Evaluate a given basic structural system case study and, under limited guidance, identify the safety factors	6
IWP	NOT APPLICABLE						

3.3 Joint design for Welding and Brazing				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	3	2
Scope:	P1	P1	P3	P3
Introduction (importance of welding joint design and groove shapes, influence on welding stresses and distortion) ……	X	X	X	X
Types of welded/brazed joints (ISO 9692, CEN, national)……	X	X	X	X
Importance of weld joint design and groove shapes, types of welded joints, design of welded joints ……	X	X	X	X
Classification of groove shapes (by material type, thickness, welding process, accessibility)..……	X	X	X	X
Tolerance requirements (ISO 13920) ……	X	X	X	X
Welding symbols on drawings, symbols for groove shapes ……	X	X	X	X
Symbolic representation of welded, brazed and soldered joints according to ISO 2553 ……	X	X	X	X
National Standards……	X	X	X	X

3.3 Joint design for Welding and Brazing – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding to be able to design and draw weld details related to a given material, wall thickness, accessibility, loading, welding process, welding position, welding symbols, available equipment, tolerances.	Demonstrate advanced knowledge and skills in designing weld details, using appropriate standards and applying correct welding and brazing symbols	6	Detail different types of welded joints, according to ISO 9692 or national standards	Apply appropriate weld symbols to drawings according to ISO 2553 or national standards Interpret appropriate standards to determine the shape and size of weld required	Appraise, autonomously, a certain welded fabrication case study, analysing it to define the type and size of weld Produce a drawing to communicate the weld design required to achieve a specified performance	8
IWS	Apply specialised understanding of the requirements and gain basic knowledge of the of the design of weld details related to a given material, wall thickness, accessibility, loading,	Demonstrate specialised theoretical knowledge and practical skills in applying the appropriate standards for weld joints and using appropriate welding and brazing symbols	5	Identify different types of welded joints, according to ISO 9692 or national standards Identify weld symbols according to ISO 2553 or national standards	Interpret, correctly, weld symbols to identify the shape, size and position of joints	Evaluate, under limited guidance, a given welded fabrication case study, identifying in the fabrication drawings the welding symbols and relating them to the specific weld joints.	6

	welding process, welding position, welding symbols, available equipment, tolerances.						
IWP	Apply basic knowledge of the design of weld details related to a given material, wall thickness, accessibility, loading, welding process, welding position, welding symbols, available equipment, tolerances.	Demonstrate basic theoretical knowledge and practical skills in applying the appropriate standards for weld joints and using appropriate welding and brazing symbols	**4**	Outline different types of welded and brazed joint, according to ISO 9692, CEN, and national standards.	Make a proper use of welded joints symbols in line to the material properties e.g. chemical composition, thickness, and weld joint Choose design symbol according to the brazing, soldering and welding process used	Evaluate with a limited autonomy a given welded fabrication case study, and under guidance identifying in the fabrication drawings the welding symbols and relating them to the specific weld joints	**5**

3.4 Basics of weld design				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	6	6	4	0
Scope:	P3	P3	P3	-
Types of stresses in welded joints (nominal stress, hot spot stress, notch stress) ……..	X	X	X	-
Stresses in butt welds, stresses in fillet welds ……	X	X	X	-
Calculation of cross section variables of welded joints ……..……	X	X	X	-
Determination of nominal stresses in single welded joints ……..…	X	X	X	-
Determination of reference values of stresses due to multi-axial stressing.	X	X	-	-
Determination of design resistance of arc-welded and resistance-welded joints ……..……..….	X	X	-	-
Worked examples of calculation of nominal stresses in welded joints …….	X	X	-	-
Principal stresses, nominal/normal stress, shear stress, Mohr circle…….....	X	X	-	-
Stress concentration, factor-k, SCF elastic, strain concentration factor…...	X	X	-	-
Constraint factor. Stress calculation by finite elements method. Experimental elasticity: strain gauges, photoelasticity, method Moiré, holography	X	X	-	-

3.4 Basics of weld design – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced and detailed understanding of	Demonstrate advanced knowledge and skills in calculating internal forces	6	Explain in depth the different types of stresses in welded joints	Calculate in detail simple welded joints, nominal	Appraise, autonomously, a certain welded fabrication case study, analysing it and	12

	the relationship between external loads on structures, internal forces and the stresses induced especially with regards to welds.	of simple welded joints, nominal stress and combined stresses in welds			stresses and combined stresses in welds	calculating simple welded joints, nominal and combined stresses in weld joints. Appraise, autonomously, alternative solutions for a certain welded fabrication case study, giving information if needed.	
IWS	Apply specialised understanding of the requirements and gain basic knowledge of the relationship between external loads on structures, internal forces and the stresses induced especially with regards to welds.	Demonstrate specialised theoretical knowledge and practical skills in outlining the different types of stresses in welded joints and describing simple weld joints and cross sections for welded joints	5	Identify the different types of stresses in welded joints. Describe simple welded joints Describe cross sections for welded joints		Evaluate, under limited guidance, a given welded fabrication case study, and identify simple joints and cross sections welded joints.	6
IWP	NOT APPLICALE						

3.5 Behaviour of welded structures under different types of loading				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	2	1	0
Scope:	P3	P3	P3	-
Static strength	X	X	X	-
Elevated temperature strength	X	X	X	-
Low-temperature strength	X	X	-	-
Creep resistance	X	X	-	-
Impact behaviour	X	X	-	-
Influence of notches and weld defects	X	X	X	-
Types of failure (ductile fracture, fatigue fracture, brittle fracture, lamellar tearing)	X	X	X	-
Selection of steel quality groups, Z-quality.....	X	X	-	-
Typical data for common steels.....	X	X	-	-
Use of standards and specifications	X	X	-	-
Collecting and processing experimental stress/strain data.....	X	-	-	-

3.5 Behaviour of welded structures under different types of loading – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding in detail of the different types of loading and the influence of ambient conditions on structures.	Demonstrate highly specialised knowledge and skills in selecting and predicting the appropriate materials that meet strength/temperature requirements	7	Explain in depth the requirements according different types of loading and temperatures Detail different types of fracture	Deduce for a certain application the materials that meet strength/temperature requirements Predict appropriate materials for use in specific applications.	Appraise, with full autonomy, a certain welded fabrication case study, analysing it, defining or checking if the materials that will be used in the fabrication are according to the requirements. Appraise, with full autonomy, if needed alternative solutions for a certain welded fabrication case study, giving information.	8
IWT	Apply advanced understanding of the different types of loading and the influence of ambient conditions on structures.	Demonstrate advanced knowledge and skills in selecting appropriate materials or group of materials that meet strength/temperature requirements	6	Explain the requirements according to different types of loading and temperatures Define different types of fracture	Select appropriate materials for specific applications using design data and appropriate calculations. Select groups of materials which meet strength / temperature requirements	Appraise, autonomously, a given welded fabrication case study, analysing its specific application and recommending or checking if the materials that will be used in the fabrication are according to the requirements.	4

						Appraise, autonomously, alternative solutions, if needed, for a given welded fabrication case study.	
IWS	Apply specialised understanding of the requirements and gain basic knowledge of the different types of loading and the influence of ambient conditions on structures.	Demonstrate specialised knowledge and skills in identifying groups of materials which meet strength and temperature requirements	5	Outline the requirements for the construction according to different types of loading and temperatures Recognise the various types of fracture Identify globally groups of materials which meet strength / temperature requirements.	Select appropriate material groups to meet specified requirements	Evaluate, with reduced direction, a given welded fabrication case study, identifying the materials groups that meet the construction requirements.	1,5
IWP	NOT APPLICALE						

3.6 Design of welded structures with predominantly static loading				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	8	5	3	2
Scope:	P3	P3	P3	P3
Steel constructions including lightweight structures ……	X	X	X	-
Structural details e.g. (stiffeners, knots, columns, base- and cap-plates, reinforced structures, supports, frame-corners, frame structures, trusses, nodal joints, weld connections, braces / bracing, lattice work structures, etc.) ……	X	X	X	-
Use of different types of welds related to joint types ……	X	X	X	X
Use of standards and specifications ……	X	X	X	X
Worked examples ……	X	X	-	-

3.6 Design of welded structures with predominantly static loading – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding how to design and calculate joints and relevant details of welded metallic structures	Demonstrate highly specialised knowledge and skills explaining and calculating appropriate weld geometry, relevant weld stresses and the advantages and disadvantages of the different	7	Explain in depth the principles of design of different connection zones Detail the stresses in frames Detail the stresses in welds in frames based on known or predicted forces	Calculate the relevant weld stresses and the appropriate weld geometry and position to maximise integrity and safety	Appraise, with full autonomy, a certain case study of welded metallic structure fabrication, analysing it and calculating the weld geometries and relevant weld stresses.	16

		types of welds in welded structures with static loading		Explain in depth the advantages and disadvantages of different types of welds		Appraise, with full autonomy, alternative solutions, if needed, for a certain case study of welded metallic structure fabrication, giving information.	
IWT	Apply advanced understanding how to design joints and relevant details of welded metallic structures	Demonstrate advanced knowledge and skills in explaining the design of welded structures with static loading	6	Explain the design of different connection zones. Define the stresses in frames Nominate the stresses in welds in frames Explain the advantages and disadvantages of different types of welds	Using specified material data calculate the relevant weld stresses and the appropriate weld geometry and position to maximise integrity and safety.	Appraise, autonomously, a given case study of welded metallic structure fabrication, analysing it and nominating the relevant weld stresses. Appraise, autonomously, alternative solutions, if needed, for a certain case study of welded metallic structure fabrication, giving information.	10
IWS	Apply specialised understanding of the requirements and gain basic knowledge of the identification of joints and relevant details of welded metallic structures.	Demonstrate specialised knowledge and skills in the factors that influence the performance of a weld joint s with static loading	5	Recognise the significance of appropriate weld geometry Describe the advantages and disadvantages of different types of welds Identify different connection zones. Identify stresses in structural details.	Using specified material data, predict the nature and location of relevant weld stresses for a given weld geometry and position	Evaluate, under limited guidance, a given case study of welded metallic structure fabrication, identifying the different connections zones and verify that the weld geometry is appropriate to maximise integrity and safety	4,5
IWP	Apply basic knowledge of identification of joints and relevant details of welded metallic structures.	Demonstrate theoretical knowledge and practical skills in the factors that influence the performance of a weld joint with static loading.	4	Outline the most common advantages and disadvantages of different welded joint types and profiles if static loading	Check simple metallic structures and joint geometrical form/shape, surface and types to the static loading	Evaluate with a limited autonomy a given welded metallic structure fabrication case study, and under supervision, identifying the differences between similar profiles and the influence of the geometrical shape of the surface	4

3.7 Behaviour of welded structures under cyclic loading				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	8	5	2	1
Scope:	P3	P3	P3	P3
Types and variables of cyclic loading …….……..	X	X	X	X
Statistical stress analysis on real structures ……	X	X	-	-
S-N diagram ……..	X	X	X	-
Stress collective …….....	X	X	-	-
Fatigue strength (low cycle, and others)……....	X	X	X	X
Effect of mean stress including residual stresses…….….....	X	X	-	-
Effect of stress range ……...	X	X	-	-
Stress distribution ……	X	X	X	X
Influence of notches ……	X	X	X	X
Influence of weld imperfections ……..	X	X	X	X
Fatigue improvement technique (needle peening, TIG dressing, burr grinding, hammering, stress relieving, etc.) ……..	X	X	X	X
Standards ISO, CEN and National ……....	X	X	X	X
Palmgren-Miner rule……..…….....….....	X	-	-	-
Classification of weld joints ……	X	-	-	-

3.7 Behaviour of welded structures under cyclic loading – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the development of fatigue, calculation of load cycles, the influence of notches and their avoidance.	Demonstrate highly specialised knowledge and skills explaining S-N Diagram, calculating the stress ratio and the influence of notches and weld defects	7	Explain in depth the methods of counting load cycles Detail the influence of notches and weld defects Explain in depth the methods for improving fatigue performance	Draw and interpret an S-N diagram. Calculate stress ratio	Appraise, with full autonomy, a certain welded metallic structure fabrication case study, analysing it, and justifying the methods to be applied to improve its fatigue performance	16
IWT	Apply advanced understanding of the development of fatigue, calculation of load cycles, the influence of notches and their avoidance	Demonstrate advanced knowledge and skills in using S-N diagrams and defining the influence of notches and weld defects	6	Explain the methods applied to welds for improved fatigue performance Define the influence of notches and weld defects.	Draw and use an S-N diagram, and define its limitations with respect to accuracy	Appraise, autonomously, a given case study of welded metallic structure fabrication, analysing it and defining the methods that will improve its fatigue performance.	10
IWS	Apply specialised understanding of the requirements and gain basic knowledge of the fatigue and the influence	Demonstrate specialised knowledge and skills in describing the influence of notches and weld defects	5	Describe the influence of notches and weld defects. Recognise possible modifications to welds for improve performance	Use an S-N diagram	Evaluate, under limited guidance, a given case study of welded metallic structure fab-	3

	of notches and their avoidance	and how to improve the fatigue performance of weldments under cycle loading				rication, identifying the possible modifications to improve fatigue performance.	
IWP	Apply basic knowledge of fatigue and the influence of notches and their avoidance.	Demonstrate theoretical knowledge and practical skills in describing the influence of notches and weld defects and how to improve the fatigue performance of weldments under cycle loading.	4	Outline the most common stresses the weld defects and improving the fatigue value of the welded joint. Identify the most common notches and weld defects Interpret the influence of notches and weld defects on the quality and lifetime of welded details.	Point out the characteristics phenomenon of cyclic load of welded structures Carry out the implementation of recommendations for fatigue improvement of welded joints	Evaluate with a limited autonomy a given welded metallic structure fabrication case study, and under supervision, identifying simple recommendations to improve the fatigue performance of a weld joint	2

3.8 Design of cyclic loaded welded structures				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	8	4	2	0
Scope:	P3	P3	P3	-
Range of application: bridges, cranes, machines, ships and offshore constructions, chimneys, towers and masts, vehicles (cars, trucks, railway vehicles), etc.....	X	X	X	-
Acceptance criteria ……...	X	X	X	-
Dimensioning according to different standards and specifications …..……	X	X	-	-
Worked examples ……	X	X	-	-
Calculation methods……..	X	X	-	-

3.8 Design of cyclic loaded welded structures – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the different design methods in the range of application.	Demonstrate highly specialised knowledge and skills in dimensioning according different standards and specifications and calculation methods	7	Detail the influence of notch effects on the classification of welded joints Interpret appropriate standards Compare details in different standards and classify them	Interpret and apply the principles of design Design welded joints in accordance with given details	Appraise, with full autonomy, a certain case study of welded metallic structure fabrication, analysing it and designing weld joints, justifying the output against the minimum design criteria	16
IWT	Apply advanced understanding	Demonstrate advanced knowledge and skills in	6	Define the influence of notch effects on the classification of welded joints	Select and apply the principles of design	Appraise, autonomously, a given case study of welded metallic structure fabrication,	8

	of the different design methods in the range of application	selecting the principles in design		Compare details in different standards and classify them	Design welded joints in accordance with given details	analysing it and designing weld joints, comparing the output with the minimum design criteria	
IWS	Apply specialised understanding of the requirements and gain specialised knowledge of the different design methods in the range of application	Demonstrate specialised knowledge and skills in knowing the typical range of application	5	Describe the design of welded joints in accordance with given details Recognise the influence of notch effects	Apply the principles of design	Evaluate, under limited guidance, a given welded metallic structure fabrication case study, identifying the influence of notch effects on the classification of welded joints.	3
IWP	NOT APPLICABLE						

3.9 Design of welded pressure equipment

Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	6	4	2	1
Scope:	P3	P3	P3	P3
Construction of boilers, pressure vessels, pipelines, etc…….....	X	X	X	X
Calculation (formulae) of the welds ……..	X	X	-	-
High and low temperatures applications ……..	X	X	X	X
Details of design (flanges, nozzles, shells, compensating plates etc.) ……	X	X	X	X
Use of laws and design rules, standards and specifications …….....	X	X	X	-
Worked examples of construction and design ……	X	X	X	-
Standards (ISO, CEN and National) ……..……..…….	X	X	-	-

3.9 Design of welded pressure equipment – LEARNING OUTCOMES

	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the special requirements of design and construction of structural elements in this field of application with regards to the welds	Demonstrate highly specialised knowledge and skills in calculating circumferential and longitudinal welds, using laws, design rules and specifications for pressure vessels	7	Derive a detailed analysis of a given weld for a particular structural application Interpret appropriate pressure equipment design standards Detail the advantages of different structural details	Calculate and design from a known level of stress the most appropriate circumferential and longitudinal joint size, and advise on any positional or geometrical modifications	Appraise, with full autonomy, a certain pressure vessel fabrication case study, analysing it and designing weld joints, justifying the output against the minimum design criteria	12

IWT	Apply advanced understanding of the special requirements of design and construction of structural elements in this field of application with regard to the welds.	Demonstrate advanced knowledge and skills in calculating circumferential and longitudinal welds, using laws, design rules and specifications for pressure vessels	6	Define the advantages of different structural details	Select appropriate standards Calculate from a known level of stress the most appropriate circumferential and longitudinal joint size, and advise on any positional or geometrical modifications	Appraise, autonomously, a certain pressure vessel fabrication case study and designing weld joints, comparing the output with the minimum design criteria	8
IWS	Apply specialised understanding of the requirements and gain specialised knowledge of the special requirements of design and construction of structural elements in this field of application with regards to the welds.	Demonstrate specialised knowledge and skills in describing the design of given structural weld details for pressure vessels	5	Outline the advantages of different weld details List the most import precautions when welding a pressure vessel	Describe the design of given structural weld details.	Evaluate, under limited guidance, a certain pressure vessel fabrication case study, identifying the type of weld joints that should be applied and also the specific precautions to avoid problems	3
IWP	Apply basic knowledge of the special requirements of design and construction of structural elements in this field of application with regard to the welds.	Demonstrate fundamental knowledge and skills in design and construction of welded pressure equipment.	4	List all kinds of pressure equipment's and pipelines under legal regulations and standards which could be operated on high and low temperatures	Make use of welding process according to the drawing of welding pressure equipment. Make use of pipelines according to base material and temperature. Compare the advantages and disadvantages of different weld details at the area /manufacturing/ of pressure equipment Select the legal rules and the welding process to the welded joints.	Evaluate with a limited autonomy a certain pressure vessel fabrication case study, and under supervision identifying type of weld joints that should be applied and also the specific precautions	2

3.10 Design of aluminium alloys structures				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	2	1	0
Scope:	P3	P3	P3	-
Comparison of design between steel and aluminium structures ……....	X	X	X	-
Lightweight structures …….....	X	X	-	-
Standard alloys for practical use and relevant stresses and strains ……	X	X	-	-
Effects of heat affected zone (HAZ) (softening) ……..……....	X	X	X	-
Special design principles regarding profiles ……	X	X	-	-
Significance of defects ……	X	X	X	-
Range of application (vehicles, rolling stocks, ships, aircraft, vessels and space) ……	X	X	X	-
Dimensioning according to different standards and specifications ……..…	X	X	X	-
Worked examples ……..……	X	X	-	-

3.10 Design of aluminium alloys structures – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the behaviour of welded aluminium structures with respect to strength, stresses and design	Demonstrate highly specialised knowledge and skills in predicting the behaviour of the heat affected zone, selecting the correct alloys for a given application and dimensioning according to different standards and specifications	7	Differentiate between the design requirements for steel and aluminium welded structures Explain in depth the occurrence of softening in the heat affected zone for a given welded aluminium structure Explain in depth how to solve the most common imperfections associated with aluminium welds Detail the causes and development of stresses and strains in an aluminium weld.	Design of optimum aluminium weld profiles and geometries for optimum performance in given applications Deduce the correct selection of alloys for given applications Predict the strength of different aluminium alloys	Appraise, with full autonomy, a certain case study of aluminium welded fabrication, analysing it and designing weld joints in accordance with given requirements and justifying the selection of weld sizes and geometries	8
IWT	Apply advanced understanding of the behaviour of welded aluminium structures with respect to strength, stresses and design.	Demonstrate advanced knowledge and skills in comparing common aluminium welded joints and defining the advantages against steel constructions	6	Differentiate between the design requirements for steel and aluminium welded structures Explain how to minimize the softening of the heat affected zone Explain how to solve the most common imperfections associated with aluminium welds Define the advantages of aluminium weld joints over those of steel joints	Select common aluminium weld joints for typical applications and compare their characteristics	Appraise, autonomously, a certain case study of aluminium welded fabrication, analysing it and designing weld joints in accordance with given requirements and comparing the selection of weld sizes and geometries	4

IWS	Apply specialised understanding of the requirements and gain basic about the behaviour of welded aluminium structures with respect to strength, stresses and design.	Demonstrate specialised knowledge and skills in recognising the common aluminium imperfections and solutions to avoid them	5	Identify some typical applications of aluminium joints and describe the advantages against steel construction. Identify typical aluminium joints and joint preparations	Recognise the common aluminium imperfections and propose solutions to avoid them.	Evaluate, with reduced direction, a certain case study of aluminium welded fabrication, identifying the type of welded joints that should be applied and also the specific precautions to avoid problems.	1,5
IWP	NOT APPLICABLE						

3.11 Introduction to fracture mechanics				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	2	0	0
Scope:	P3	P3	-	-
Viewpoint of fracture mechanics ……	X	X	-	-
Application of fracture mechanics ……	X	X	-	-
Linear elastic fracture mechanics ……	X	X	-	-
Fundamentals of elastic-plastic fracture mechanics……	X	X	-	-
Critical flaw size, K_{Ic}-value ……	X	X	-	-
Fracture mechanics testing (CTOD, etc.) ……	X	-	-	-
Different assessment method……	X	-	-	-
Sub-critical crack growth ……	X	X	-	-
Fatigue testing ……	X	X	-	-
Standards global (ISO), regional (CEN) and National ……	X	-	-	-

3.11 Introduction to fracture mechanics – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding in detail the use of fracture mechanics for welded structures.	Demonstrate highly specialised knowledge and skills in detailing the influence factors for linear-elastic and elastic-plastic fracture mechanics	7	Explain in depth the principles of linear-elastic and elastic-plastic fracture mechanics Detail the influence factors for linear-elastic and elastic-plastic fracture mechanics. Explain in depth the use of fracture mechanics for dynamically loaded structures	Determine the fracture mechanics testing and assessment methods for a certain application.	Appraise, with full autonomy, a certain welded fabrication case study, using the fracture mechanics principles to evaluate the weld joints performance and to determine the tests that are needed for evaluation	8

IWT	Apply advanced understanding of the use of fracture mechanics for welded structures	Demonstrate advanced knowledge and skills in defining the influence factors for linear-elastic and elastic-plastic fracture mechanics	6	Explain the principles of linear-elastic and elastic-plastic fracture mechanics Define the influence factors for linear-elastic and elastic-plastic fracture mechanics. Explain the use of fracture mechanics for dynamically loaded structures	Select the fracture mechanics testing and assessment methods for a certain application.	Appraise, autonomously, a certain welded fabrication case study, using the fracture mechanics principles to evaluate the weld joints performance.	4
IWS & IWP	NOT APPLICABLE						

Module 3 – Construction and Design

Module 3	IWE		IWT		IWS		IWP	
	MT	P1 *	MT	P1 *	MT	P1 *	MT	P1 *
Teaching Hours	**62**	**14**	**44**	**14**	**24**	**4**	**6**	**0**

***** P1 = Part 1, Figures under P1 are given for the Standard Route (see 4.1)

Module 4: Fabrication, applications engineering

Characterization of the general description of Module 4 – Fabrication, applications engineering, describing the Qualification descriptors in terms of Knowledge – K, Skills – S, Competences - C for each IIW welding coordination qualification

COMPETENCE UNIT 4: FABRICATION, APPLICATIONS ENGINEERING							
QUALIFICATION	**KNOWLEDGE**	**SKILLS**	**COMPETENCES**	**EQF LEVEL**	**TEACH-ING HOURS**	**WORK-LOAD (Hours)**	**ECVET POINTS**
INTERNATIONAL WELDING ENGINEER	Highly specialised knowledge, original thinking, research and critical assessment of the principles and applicability concerning the quality assurance and quality control applied to welding and related technologies.	Highly specialised problem-solving skills, including critical evaluation, allowing to define or develop the best technical and economical solutions for quality assurance and quality control of welded products in complex and unpredictable conditions.	Manage and transform the welding applications concerning the quality assurance and quality control of welded products in a highly complex context. Act as the full responsible person for the definition of the welding and related personnel's tasks.	7	116	232	20
INTERNATIONA WELDING TECHNOLOGIST	Advanced knowledge and critical understanding of the principles and applicability concerning the quality assurance and quality control applied to welding and related technologies.	Advanced problem-solving skills including critical evaluation, allowing to choose the proper technical and economical solutions for quality assurance and quality control of welded products in complex and unpredictable conditions.	Manage the applications concerning the quality assurance and quality control of welded products in a highly complex context. Act autonomously as the responsible person for decision making and the definition of the welding and related personnel's tasks.	6	83	125	10
INTERNATIONA WELDING SPECIALIST	Specialised, factual and theoretical knowledge of the theory, prinsciples and applicability concerning the quality assurance and quality control applied to welding and related technologies.	Specialised range of cognitive and practical skills, allowing to develop solutions or choose the appropriate methods for quality assurance and quality control of welded products on common/regular problems.	Manage and supervise common or standard applications concerning the quality assurance and quality control of welded products in an unpredictable context. Take responsibility with limited autonomy for decision making in common or standard work and supervise the welding and related personnel's tasks.	4	56	84	10
INTERNATIONA WELDING PRACTITIONER	Fundamental factual and theoretical knowledge concerning the quality assurance and quality control applied to welding and related technologies.	Fundamental range of cognitive and practical skills required to identify/choose the proper solutions for quality assurance and quality control of welded products on basic and specific problems.	Self-manage within the guidelines of work, the applications concerning quality assurance and quality control of welded products usually predictable but subject to change. Take responsibility without autonomy for decision-making in basic work and supervise basic tasks of welding and related personnel.	4	29	49	1,6

4.1 Introduction to quality assurance in welded fabrication				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	8	8	4	2
Scope:	P3	P3	P3	P3
Concept of quality assurance and quality control (including analysis, continuous improvement)……	X	X	X	X
Weldability ISO/TR 581……..……..	X	X	-	-
Testing and Inspection Plan (the goal, content and sources to develop it)..	X	X	X	X
Audit of plant……..……	X	X	X	
Personnel and Equipment…….…...	X	X	X	X
Maintenance…….……..	X	X	X	X
Inspection……...	X	X	X	X
Activities of the welding engineer/technologist/specialist/practitioner in the different functions in industry (ISO 14731) e.g. RWC…….....	X	X	X	X
Standards (ISO 9000, ISO 3834, national and international standards). Development of quality plans - ISO 10005).....……	X	X	X	-
Software (overview, availability, demonstration, use)……..	X	X	X	-

4.1 Introduction to quality assurance in welded fabrication – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the principles of quality assurance and quality control, the related standards and their application to welded fabrication as a special process.	Demonstrate advanced knowledge and skills in quality assurance and quality control and apply them to management of complex challenges in welded fabrication.	6	Analyse the principles of quality assurance, quality control and inspection systems in relation to welded fabrication to realise its specific quality requirements Define the essential elements of quality control procedures and quality plans in relation to welded fabrication quality requirements. Define the purpose of an audit plan and considering its influence in welded fabrication quality requirements. Define audit principles, illustrate how each can affect the reliability of results, and compare their impacts on welded fabrication quality requirements.	Choose quality assurance, quality control and inspections systems to determine particular quality outcomes in welded fabrication. Design and construct elements of quality control procedures and quality plans to determine given welded fabrication quality requirements. Interpret relevant standards (e.g. ISO 9000, and ISO 3834).	Appraise a given welded fabrication case study, analyse its specific quality requirements. Formulate a quality assurance solution, identifying alternatives where appropriate. Create a quality audit plan and undertake a case study audit of a pre-defined welding fabrication identifying shortfalls and non-conformities	16

				Compare the personnel and equipment factors that have a major effect on welded fabrication quality Define the quality assurance tasks of the welding coordinator responsible for welded fabrication/ manufacture in relation with the impact of the specific tasks on weld quality.			
IWS	Apply understanding of the principles of quality assurance and quality control in the scope of the related standards and their application to welded fabrication as a special process.	Demonstrate specialised knowledge and skills in quality assurance and quality control and apply them to management of complex challenges in welded fabrication.	5	List the main differences between quality assurance, quality control and inspection systems by describing their usage for welded fabrication. List the basic factors related to personnel and equipment, by describing their influence on the quality of welded fabrication. Outline the role of the Welding Specialist in the fabrication industry.	Demonstrate effective writing of quality control procedures. Demonstrate correct use of standards (e.g. ISO 9000, and ISO 3834).	Appraise a given welded fabrication case study, interpret the specific quality requirements, and compile a quality control procedure. Appraise an audit report and provide appropriate corrective and preventive actions for non-conformities	6
IWP	Apply basic knowledge of principles of quality assurance and quality Control, and recognise the related standards and their application to welded fabrication as a special process.	Demonstrate fundamental knowledge and skills in quality assurance and quality control, applying them to the management of simple welded fabrication.	4	Identify the goals and the differences of quality assurance and quality control quality to the own practice and work. Outline the most common factors related to personnel and equipment, which influence the quality of a welded construction. Identify the role of the Welding Practitioner in the fabrication industry	Use quality control procedures, and instructions in welding fabrication. Make use of standards (e.g. ISO 9000, and ISO 3834) in order to guarantee the quality of the welded fabrication.	Appraise with limited autonomy a given welded fabrication case study, identifying some specific/basic quality requirements.	3

4.2 Quality control during manufacture				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	16	12	10	6
Scope:	P3	P3	P3	P3
Advantages to the quality of brazed and welded constructions….....	X	X	X	X
Brazing and Welding sequence …..……	X	X	X	-
Welding coordination and inspection personnel; qualification tasks and responsibilities (ISO 14731, ISO 9712, CEN and National standards).....	X	X	X	X
Brazer and Welder Approval /Qualification and Brazing and Welding Procedure Qualification - Introduction/Overview……..……	X	X	X	X
Brazer and Welder Approval/Qualification (ISO 9606, CEN and National Standards).....	X	X	X	X
Brazing and Welding Procedure Specification – The goal, how to create and develop (ISO 15607 and 15609, CEN and National Standards)…..….	X	X	X	X
Brazing and Welding Procedure Qualification (ISO 15610, 156111, 15612, 15613 and 15614~~)~~, CEN and National standards).....….	X	X	X	X
Brazing and Welding Operator Qualification (ISO 14732, CEN and National Standards).....	X	X	X	X
Traceability (materials identification, welder/operator, procedures, certificates) .....….	X	X	X	-
Practical exercises:				
IWE - Welding procedure qualification 4 hours from 16				
IWE - Welder and welder operator qualification 4 hours from 16				
IWT - Welding procedure qualification 2 hours from 12				
IWT - Welder and welder operator qualification 2 hours from 12				
IWS - Welding procedure qualification 2 hours from 10				
IWS - Welder and welder operator qualification 2 hours from 10				
IWP - Welding procedure qualification 1 hours from 6				
IWP - Welder and welder operator qualification 1 hours from 6				

4.2 Quality control during manufacture – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply highly specialised understanding of the requirements and function of Quality Control during manufacture,	Demonstrate highly specialised knowledge and skills in quality control and apply them to solving quality problems applied	7	Explain in detail the essential elements of WPS/WPQR/pWPS BPS/pBPS/BPQR and the main advantages to the quality of welded fabrication requirements.	Compile WPSs for welded components.	Appraise a given welded fabrication case study, define its specific requirements, and create a WPS, identifying alternatives where appropriate.	32

	the standards related to brazing and welding operators and brazing and welding procedure qualification including joint traceability methods, the need for calibration, and monitoring of process parameters.	manufacture of welded products.		Explain the purpose of a welder qualification and the main advantages to the quality of welded fabrication Clarify the purpose of a welding operator qualification and its outcomes with the welded fabrication quality requirements. Clarify the welding control tasks of the welding coordinator responsible for welded fabrication/ manufacture. Explain the impact of the specific tasks on weld quality. Classify the welding control tasks of welding inspectors. Explain the impact of the specific tasks on weld quality.	Discuss WPSs compliance with the requirements of relevant national and international standards. Discuss the requirements of relevant standards for the qualification of a WPS. Determine the main variables for a particular WPS qualification and its range of qualification. Discuss the requirements of relevant standards for welder qualification. Determine the main variables for a particular welder qualification and its range of qualification. Discuss the requirements of relevant standards for welder qualification. Determine the main variables for a particular welder qualification and its range of qualification. Discuss the requirements of relevant standards for material traceability. Elaborate the essential content of materials procedures and certificates.	Appraise a given welded fabrication case study, evaluate the WPS and welder/welding operator documents against relevant standards, and modify to demonstrate full compliance with requirements.	
IWT	Apply advanced understanding of the requirements and function of Quality Control during manufacture, the standards related to brazing and welding operators and brazing and welding procedure qualification including joint traceability methods, the need for calibration, and monitoring of process parameters.	Demonstrate advanced knowledge and skills in quality control and apply them to solving quality problems applied manufacture of welded products.	6	Explain the essential elements of WPS/WPQR/pWPS BPS/pBPS/BPQR and their relationships with welded fabrication quality requirements. Interpret the requirements of relevant standards for the qualification of a WPS. Explain the purpose of a welder qualification and how its outcomes relate to welded fabrication quality requirements. Interpret the requirements of relevant standards for welder qualification. Explain the purpose of a welding operator qualification and how its outcomes relate to welded fabrication quality requirements.	Compile WPSs for welded components. Evaluate their compliance with the requirements of relevant national and international standards. Determine the main variables for a particular WPS qualification and its range of qualification. Determine the main variables for a particular welder qualification and its range of qualification. Determine the main variables for a particular welder qualification and its range of qualification. Interpret the requirements of relevant standards for material traceability, defining the essential content of materials procedures and certificates.	Appraise a given welded fabrication case study, analyse its specific requirements, and compile a WPS, identifying alternatives where appropriate. Appraise a given welded fabrication case study, evaluate the WPS and welder/welding operator documents against relevant standards, and modify to demonstrate full compliance with requirements.	18

				Interpret the requirements of relevant standards for welder qualification. Interpret the requirements of relevant standards for material traceability. Explain the welding control tasks of the welding coordinator responsible for welded fabrication/ manufacture Define the welding control tasks of welding inspectors.			
IWS	Apply understanding of the requirements and function of Quality Control during manufacture, the standards related to brazing and welding operators and brazing and welding procedure qualification including joint traceability methods, the need for calibration, and monitoring of process parameters.	Demonstrate specialised knowledge and skills in quality control and apply them to solving quality problems applied manufacture of welded products.	4	Recognise the main purpose of a WPS/WPQR/pWPS BPS/pBPS/BPQR and the advantages to the quality of welded fabrication. Recognise the main variables for a particular WPS qualification and its range of qualification in accordance with National and/or International standards. List the main purposes of welder qualification and relate them to the main advantages to the quality of welded fabrication. Recognise the main variables for a particular welder qualification and its range of qualification. List the main purpose of a welding operator qualification and relate them to the main advantages to the quality of welded fabrication. IIST the traceability requirements for materials procedures and certificates and give examples	Organise WPSs for welded components in accordance with national and international standards. Use correctly the standards for the qualification of a WPS, Use correctly the standards for welder qualification Use correctly the standards for welding operator qualification. Determine the main variables for a particular welding operator qualification and its range of qualification.	Appraise a given welded fabrication case study, and compile a WPS in accordance with a relevant standard. Appraise a given welded fabrication case study, evaluate the WPS and welder/welding operator documents against relevant standards, and identify any compliance issues.	15
IWP	Apply basic knowledge of the requirements and function of Quality Control during manufacture, the standards related to brazing and welding operators and brazing and welding procedure	Demonstrate fundamental knowledge and skills in quality control and apply them to solving quality simple problems in manufacture of welded products.	4	Outline the purpose of WPS and of welder qualification, and point out the most common advantages to the quality of the welded construction. List the main purpose of WPS/WPQR/pWS, and related them to their advantages to the quality of welded fabrication.	Check the main variables for a certain WPS qualification and its range of approval Check the main variables for a certain welder, welding operator qualification and its range of approval	Appraise with limited autonomy a given welded fabrication case study, checking the WPS and welder/welding operator documents against relevant standards and specifications.	9

	qualification including joint traceability methods, the need for calibration, and monitoring of process parameters.			List the main purposes of welder, brazer and welding operator qualification and relate them to the main advantages to the quality of welded fabrication. Outline the most common ISO standards used for welder, brazer, welding operators qualification, and approval of welding procedures and developing of welding procedures specifications and the main features for each propose			

4.3 Residual Stresses and Distortion				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	6	4	2	2
Scope:	P3	P3	P3	P3
Influencing factors ……	X	X	X	X
Thermal data of the materials ……	X	X	-	-
Origin of the residual stresses and deformation ……..	X	X	X	X
Relationship between the material at a certain temperature and its mechanical characteristics……..……...	X	X	X	X
Magnitude of longitudinal and transverse shrinkage stresses ……..	X	X	X	X
Distribution of the residual stresses at weld (parallel to the weld axis, perpendicular, and through thickness, influence of the material thickness)…..	X	X	X	X
Relationship between heat input, shrinkage stresses and distortion ……	X	X	X	X
Methods of residual stress measurement ……	X	X	-	-
Welding sequence techniques…….....	X	X	X	X
Effects of residual stresses on the behaviour of the structure in service…..	X	X	X	X
Methods of reducing residual stresses or distortion …….....	X	X	X	X
Examples to prevent and control of distortion...……	X	X	X	X
Weld straightening, correction and removal of welding deformation (pressing, rolling, local heating, etc.)……	X	X	X	X

4.3 Residual Stresses and Distortion – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**

IWE	Apply specialised understanding of the main factors affecting welding stress and distortion in welded fabrications and how these effects can be measured and minimised.	Demonstrate highly specialised knowledge and skills in solving residual stress and distortion problems in welded fabrications.	7	Explain fully the origin, influencing factors and magnitude of residual stress and distortion in welded fabrications. Define in detail the relationship between the material at a certain temperature and its mechanical characteristics. Define in detail procedures to minimise distortion and stress.	Determine the magnitude of residual stress and distortion in welded fabrications. Predict critically the distribution of residual stresses in a weld (parallel to the weld axis, perpendicular, and through thickness, influence of the material thickness) Predict, quantitatively, the contraction and distortion in joints and structures. Predict critically how residual stresses may affect the behaviour of a structure in service.	Appraise autonomously a given welded fabrication case study, by determining the magnitude of residual stress and distortion, and propose solutions to achieve the required level of weld quality and geometrical tolerances.	12
IWT	Apply understanding of the main factors affecting welding stress and distortion in welded fabrications and how these effects can be measured and minimised.	Demonstrate advanced knowledge and skills in solving residual stress and distortion problems in welded fabrications.	6	Explain the origin and influencing factors of residual stress Relate with distortion and geometrical requirements of welded fabrication. Explain the relationship between the material at a certain temperature and its mechanical characteristics. Define procedures to minimise distortion and stress	Calculate and relate this to distortion and geometrical stability of a welded fabrication Predict the distribution of residual stresses in a weld (parallel to the weld axis, perpendicular, and through thickness, influence of the material thickness) Predict, quantitatively, the contraction and distortion in joints and structures. Predict how residual stresses may affect the behaviour of a structure in service.	Appraise a given welded fabrication case study, calculate the residual stress and distortion, and select solutions to achieve the required level of weld quality and geometrical tolerances.	6
IWS & IWP	Apply basic knowledge of the main factors affecting welding stress and distortion in welded fabrications and how these effects can be measured and minimised**.**	Demonstrate basic theoretical knowledge and practical skills in solving residual stress and distortion problems in simple welded fabrications.	4	Outline the origin and influencing factors of residual stress and distortion in welded fabrications. Identify the relationship between the material at a certain temperature and its most relevant mechanical characteristics.	Make a use of procedures to minimise distortion and stress. Determine how residual stresses may affect the behaviour of a structure in service.	Appraise with limited autonomy a given welded fabrication case study, by determining the likelihood of residual stress and distortion. Use under direction the procedures to achieve the required	3

				Outline the distribution of residual stresses in a weld (parallel to the weld axis, perpendicular, and through thickness, influence of the material thickness) Identify the most common contraction and distortion in joints and structures. Outline how residual stresses may affect the behaviour of a structure in service.		level of weld quality and geometrical tolerances.	4

4.4 Plant facilities, welding jigs and fixtures				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	4	2
Scope:	P3	P3	P3	P3
Layout of production line ……..	X	X	X	X
Jigs, fixtures and positioners (types, applications, advantages, special precautions) ……..	X	X	X	X
Roller beads, manipulators……..…	X	X	X	X
Cables, electrical connections, and special precaution……...	X	X	X	X
Operational environment……..	X	X	X	X
Auxiliary equipment (for fit up, movement, backing gas devices, flow meters, etc)……..…	X	X	X	X
Joint fit up ……..……	X	X	X	X
Tack welding (specific cares, distribution, length and their removal)……	X	X	X	X
Equipment for preheat, postheat, and other heat treatments, also temperature control including furnace and local heat treatment…..……	X	X	X	X

4.4 Plant facilities, welding jigs and fixtures – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply advanced understanding of the need for, and function of, auxiliary equipment, jigs and fixtures from the viewpoint of quality, economics and the environment.	Demonstrate advanced knowledge and skills in the application of auxiliary equipment, jigs and fixtures in the control of	6	Explain in detail the workshop layout principles for improved productivity, safety and comfort. Explain fully the advantages of using fixtures, jigs and positioners	Determine the appropriate cables, heat treatment and temperature control equipment to use the appropriate type of fixture, jig or positioner to achieve the required quality level.	Appraise a given welded fabrication case study, define the plant facilities and design the layout to maximise productivity, safety and ergonomic benefits.	8

		welding quality, economics and environmental requirements.		Explain in detail the requirements related to joint fit up and tack welding.	Decide about the appropriate cables, heat treatment and temperature control equipment.	Manage alternative options, where appropriate.	
IWS	Apply understanding of the need for, and function of, auxiliary equipment, jigs and fixtures from the viewpoint of quality, economics and the environment.	Demonstrate specialised knowledge and skills in the application of auxiliary equipment, jigs and fixtures in the control of welding quality, economics and environmental requirements	5	Recognise the principles for improved productivity, safety and comfort. Identify the advantages of using fixtures, jigs and positioners. Identify the special requirements for joint fit up and tack welding.	Check if the type of fixture, jig or positioner is suitable for a particular welded fabrication. Select the type of auxiliary equipment and cables, heat treatment and temperature control equipment to be used in a particular welded fabrication.	Appraise a given welded fabrication case study, select the fixtures, jig or positioner, and auxiliary equipment and cables, heat treatment and temperature control that will improve productivity, safety and comfort.	6
IWP	Apply basic knowledge of the need for, and function of, auxiliary equipment, jigs and fixtures from the viewpoint of quality, economics and the environment.	Demonstrate fundamental knowledge and skills in the application of auxiliary equipment, jigs and fixtures in the control of welding quality, economics and environmental requirements	4	Outline the importance of workshop layout to achieve a higher and easier production. Identify the most common advantages of using fixtures, jigs and positioners. List the most common type of fixture, jig and positioner to be used in a certain welded construction. Identify the type of auxiliary equipment and cables, heat treatment and temperature control equipment to be used in a welded fabrication. List the necessary characteristics for the auxiliary equipment to be used in a certain welded construction, cables, heat treatment equipment and temperature control. Outline the general precautions related with joint fit up and tack welding.	Choose the proper type of fixture, jig or positioner to be used for a particular welded fabrication.	Appraise with limited autonomy a given welded fabrication case study, by selecting the fixtures, jig or positioner, and auxiliary equipment and cables, heat treatment and temperature control according to productivity, safety and comfort.	4

4.5 Health and Safety				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	4	4
Scope:	P3	P3	P3	P3
Introduction to health and safety requirements …….……..	X	X	X	X
Survey of safety and environmental aspects, risk assessment …….……	X	X	X	X
Hazards of electric power ……..……..….	X	X	X	X
Electro-magnetic fields ……	X	X	X	X
Connecting of equipment ……	X	X	X	X
Problems with shielding gases ……	X	X	X	X
Radiation and eye protection ……..	X	X	X	X
Welding fume emission …….....	X	X	X	X
Exposure limits (Maximum Allowable Concentration) MAC and UEL (Upper Exposure Limit) values …….....……..	X	X	-	-
Ventilation filters (ISO 15012) and fume extraction (type of equipment and airflow)……..……..….	X	X	X	X
Ergonomics ……..……....	X	X	X	X
Determination of acceptable emissions…….……	X	X	-	-
Tests for measuring emissions ……..	X	X	-	-
Noise levels and ear protection ……..	X	X	X	X
Special risks for automated processes ……..	X	X	X	X
Standards and National regulations.....	X	X	X	X
Protective clothing……..	X	X	X	X
Health effects of grinding (vibration and dust)……...	X	X	X	X
Hazards regarding the heat (spatter, flame, combustion, fire)……	X	X	X	X
Oxygen environment enrichment……	X	X	X	X

4.5 Health and Safety – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply understanding of the health and safety hazards associated with welding and fabrication processes, including techniques to minimise them.	Demonstrate highly specialised knowledge and skills in controlling the health and safety hazards associated with welding and fabrication processes	6	Interpret fully the health and safety hazards associated with electricity, gases, fumes, fire, radiation and noise Classify the health hazards associated with the heat used in metal processing (grinding, welding spatter, flame, fire, combustion).	Discuss Health and Safety regulations, apply them to welding hazards. Assess the risk associated with welding operations. Check the welding hazards risks. Using the latest HSE COSHH descriptors identify those consumables	Appraise a given welded fabrication case study, predict the hazards, define the health and safety requirements, undertake a risk assessment and formulate the management actions to mitigate the risks.	8

				Classify safe working procedures to ensure that regulatory requirements are met. Explain the correct PPE for each hazard. Explain oxygen environment enrichment and the hazards created by it.	and substances associated with welding a fabrication		
IWS & IWP	Apply basic knowledge of the health and safety hazards associated with welding and fabrication processes, including techniques to minimise them.	Demonstrate theoretical knowledge and practical skills in controlling the health and safety hazards associated with welding and fabrication processes	4	List the health and safety hazards associated with electricity, gases, fumes, fire, radiation and noise. Interpret simple the health hazards associated with the heat used in metal processing (grinding, welding spatter, flame, fire, combustion). List the health hazards associated with the heat used in metal processing (grinding, welding spatter, flame, fire, combustion). Outline oxygen environment enrichment as a welding hazard.	Analyse how each is created and choose the actions that can mitigated in a welded fabrication environment. Apply Health and Safety regulations with respect of welding hazards. Select controls to mitigate the risks presented by welding hazards. Use safe working procedures by applying the Health and Safety regulation requirements. Use the adequate protective clothing as measure to minimise potential health and safety problems.	Appraise with limited autonomy a given welded fabrication case study, by identifying the health and safety requirements, hazards and actions to mitigate the risks.	6

4.6 Measurement, Control and Recording in Welding				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	4	4	2
Scope:	P3	P3	P3	P3
Methods of measurement (electrical parameters, gas flow rate, temperature, velocity) ……..……..	X	X	X	X
Instruments (types, measuring applications) ..……	X	X	X	X
Temperatures (ISO 13916), humidity, wind …..……....	X	X	X	X
Cooling time e.g. $\Delta t_{8/5}$ ……..	X	X	X	X
Welding parameters (voltage, current, speed, gas flow rate, etc.)…….……	X	X	X	X
Control in heat treatment (heating and cooling rate, ISO/TR 17663) ……....	X	X	X	X
Calibration and validation of equipment (ISO 17662) …….….....	X	X	-	-
Laboratory exercises: - IWE, IWT and IWS: 1 hour from 4 - IWP: 1 hour from 2				

4.6 Measurement, Control and Recording in Welding – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE & IWT	Apply understanding of the requirements for measurement, control and recording during welding and allied operations.	Demonstrate advanced knowledge and skills in measurement, control and recording of essential variables in welding	6	Explain in detail the methods of measurement used in the control of welding. Interpret the procedures for the calibration, validation and monitoring of welding operations	Apply working procedures for the correct measurement and control of welding parameters and heat treatments operations.	Appraise a given welded fabrication case study, define the requirements for calibration, validation and monitoring of welding operations, manage appropriate methods of measurement, to be applied to achieve the required level of control.	8
IWS	Apply understanding of the requirements for measurement, control and recording during welding and allied operations.	Demonstrate specialist knowledge and skills in measurement, control and recording of essential variables in welding	5	Describe the methods of measurement used in the control of welding.	Apply requirements for the calibration, validation and monitoring of welding operations.	Appraise a given welded fabrication case study. Apply the requirements for calibration, validation and monitoring of welding operations given in working procedures.	6
IWP	Apply basic knowledge of the requirements for measurement, control and recording during welding and allied operations.	Demonstrate fundamental knowledge and skills in measurement, control and recording of essential variables in welding	4	Identify the most common methods of measurement used in the control of welding.	Carry out the implementation of the requirements for the calibration, validation and monitoring of welding operations.	Appraise with limited autonomy a given welded fabrication case study, identifying the requirements for calibration, validation and monitoring of welding operations given in working procedures.	4

4.7. Imperfections and Acceptance Criteria				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	4	3	2	1
Scope:	P3	P3	P3	P3
Types of weld imperfections according to ISO 6520 standards. ..…….....	X	X	X	X
Acceptance criteria (e.g. ISO 5817, ISO 10042, ISO 13919, ISO 9013, ISO 17635).....…….....	X	X	X	X
Significance of imperfections ……..	X	X	X	-
Introduction to ISO/TR 15235……..…..……	X	X	-	-
Engineering critical assessment techniques ……..……..…	X	X	-	-

4.7 Imperfections and Acceptance Criteria – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply understanding of the principles of imperfections and acceptance criteria and fitness for purpose.	Demonstrate highly specialised knowledge and skills in determining imperfections and acceptance criteria for welded joints	7	Interpret correctly the types of weld and HAZ imperfections and how acceptance criteria are applied to them. Define if an imperfection is likely to be material related or induced during manufacturing.	Discuss the significance of imperfection size, morphology and position relative to the effect of the imperfection on structural integrity. Produce Engineering Critical Assessment.	Appraise a given welded fabrication case study, define appropriate acceptance criteria, monitor de results and make the fitness for service decision	8
IWT	Apply understanding of the principles of imperfections and acceptance criteria and fitness for purpose.	Demonstrate advanced knowledge and skills in determining imperfections and acceptance criteria for welded joints	6	Interpret the types of weld imperfections and how acceptance criteria are applied to them. Discuss the significance of imperfection size, morphology and position relative to the effect of the imperfection on structural integrity. Compare typical methods of Engineering Critical Assessment techniques.	Apply acceptance standards for weld imperfections.	Appraise a given welded fabrication case study, apply appropriate acceptance criteria, and determine the results.	4,5
IWS	Apply basic knowledge of the principles of imperfections and acceptance criteria.	Demonstrate theoretical knowledge and practical skills in determining imperfections and acceptance criteria for welded joints	4	Recognise the significance of the most common weld imperfections relative to their size, location and morphology, as given on acceptance standards.		Appraise with limited autonomy a given welded fabrication case study, by interpreting the significance of identified imperfections.	3
IWP	Apply basic knowledge of the principles of imperfections and acceptance criteria.	Demonstrate theoretical knowledge and practical skills in identifying imperfections and determining	4	Outline the types of weld imperfections and compare how acceptance criteria are applied to them.		Appraise with limited autonomy a given welded fabrication case study, by applying appropriate acceptance criteria, and determine the results.	3

		the acceptance criteria for welded joints		Identify the significance of the most common weld imperfections relative to their size, location and morphology, as given on acceptance standards.			

4.8 Non-Destructive Testing				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	18	8	8	8
Scope:	P3	P3	P3	P3
Fundamentals of NDT methods (visual, dye penetrant, magnetic particle, eddy current, acoustic emission, radiography, digital RT, ultrasonic, etc.)..	X	X	X	X
Field of application and limitations.....	X	X	X	X
Design in respect of NDT.....	X	X	X	X
Calibration.....	X	X	X	X
Interpretation (IIW Radiographic reference).....	X	X	X	X
Recording of data.....	X	X	X	X
Correct selection of the NDT methods versus application (e.g. CEN/TR 15135).....	X	X	X	X
Qualification and certification of NDT personnel (~~EN~~ ISO 9712).....	X	X	X	X
NDT procedures.....	X	X	X	X
Automation of NDT (computer aided evaluation, etc.).....	X	X	-	-
Use of standards and specifications.....	X	X	-	-
Health and safety aspects.....	X	X	X	X
Review of documents and protocols from NDT test sites.....	X	X	X	-
Laboratory exercises: - IWE: 10 hours from 18 - IWT: 5 hours from 8 - IWS: 5 hours from 8 - IWP: 5 hours from 8				

Note: Welding coordination personnel may need qualifications according to ISO 9712. The education in this guideline may be accepted by a certification body against the training requirements of ISO 9712

4.8 Non Destructive Testing – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**

IWE	Apply understanding of the use of Non Destructive Testing as applied to welding fabrications.	Demonstrate advanced knowledge and skill in the application of NDT to welded joints	7	Explain the functionality of the main NDT methods comparing their advantages and disadvantages when applied to welded fabrications. Interpret weld imperfections, relating their causes and avoidance. Explain in detail the principles of NDT interpretation	Justify the suitability of particular NDT methods for the detection of specific imperfection Apply acceptance standards for weld imperfections Apply the requirements for qualification of NDT personnel. Undertake laboratory application of relevant NDT methods to welded joints. Check the features of weld design that may prevent or adversely affect application of NDT methods. Produce safety requirements for the main NDT methods.	Appraise a given welded fabrication case study, determine the NDT requirements, define the appropriate method(s) and relevant safety requirements. Define weld design and/or fabrication sequencing to support inspection, and monitor the reports	36
IWT	Apply understanding of the use of Non Destructive Testing as applied to welding fabrications.	Demonstrate specialised knowledge and skill in the application of NDT to welded joints	6	Explain the functionality of the main NDT methods relating their advantages and disadvantages when applied to welded fabrications Interpret weld imperfections, their causes, avoidance and methods of detection Explain the principles of NDT interpretation Explain the features of weld design that may prevent or adversely affect application of NDT methods. Explain the safety requirements for the main NDT methods.	Select acceptance standards for weld imperfections Select the requirements for qualification of NDT personnel. Undertake laboratory application of relevant NDT methods to welded joints.	Appraise a given welded fabrication case study, identify the NDT requirements, select the appropriate method(s) and relevant safety requirements, choose an appropriate weld design and/or fabrication sequencing to support inspection, and evaluate the reports.	12
IWS & IWP	Apply basic knowledge of the use of Non Destructive Testing as applied to welding fabrications.	Demonstrate theoretical knowledge and practical skills in the application of NDT to welded joints	4	Outline the functionality of the main NDT methods. List the most common advantages and disadvantages of NDT methods when applied to welded fabrications. Identify the most common weld imperfections, their causes and avoidance and methods of detection	Make use of acceptance standards for weld imperfections. Undertake simple laboratory application of relevant NDT methods to welded joints.	Appraise with limited autonomy given welded fabrication case study, by identifying the NDT requirements, and selecting the appropriate method(s) and relevant safety requirements,	12

				Describe the most common principles of NDT interpretation. Recognise the features of weld design that may prevent or adversely affect application of NDT methods. Recognise the safety requirements for the main NDT methods.			

4.9 Economics and Productivity				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	8	5	2	1
Scope:	P3	P3	P3	P3
Analysis of welding costs	X	X	X	X
Deposition rate	X	X	X	X
Costs of labour	X	X	X	-
Costs of welding consumables	X	X	X	-
Costs of equipment	X	X	X	-
Return on investment	X	X	-	-
Costs of energy	X	X	-	-
Welding processes operation factor	X	X	X	X
Calculation of welding costs	X	X	X	-
Cost awareness (of labour, consumables, equipment, gases, energy, etc.)	X	X	X	X
The application of software, calculation programmes	X	X	-	-
Measures for decreasing welding costs	X	X	X	X
Mechanisation	X	X	X	X
Automation	X	X	X	X
Robotics	X	X	X	X

4.9 Economics and Productivity – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply understanding of the economics of welding operations applied to welded fabrications.	Demonstrate highly specialised knowledge and skills in economics and productivity for fabrication and manufacture of welded products.	7	Explain in detail the different elements comprising the cost of welded fabrication and how they are affected by changes in the welding variables.	Assess the cost of welding operations.	Appraise a given welded fabrication case study, determine the welding costs, recommend methods for minimising the cost of welding, and estimating the improvements.	16

				Explain correctly the techniques and technologies that can be applied to minimise welded production costs.			
IWT	Apply understanding of the economics of welding operations applied to welded fabrications.	Demonstrate advanced knowledge and skills in economics and productivity for fabrication and manufacture of welded products.	6	Explain the elements comprising the cost of welded fabrication, and how they are affected by changes in the welding variables. Explain the techniques and technologies that can be applied to reduce welded production costs	Assess the cost of welding operations.	Appraise a given welded fabrication case study, identify the factors affecting welding costs, compare options to reduce the cost of welding, and estimate the improvements.	7,5
IWS	Apply basic knowledge of the economics of welding operations applied to welded fabrications.	Demonstrate theoretical knowledge and practical skills in economics and productivity for fabrication and manufacture of welded	4	Identify the elements comprising the cost of welded fabrication.	Calculate the cost of welding operations.	Appraise a given welded fabrication case study, recognise the relevant welding and handling procedures that would reduce the cost of welding, and estimate the improvements.	3
IWP	Apply basic knowledge of the economics of welding operations applied to welded fabrications.	Demonstrate theoretical knowledge and practical skills in economics and productivity for fabrication and manufacture of welded joints.	4	Identify the elements comprising the cost of welded fabrication. Associate the welding processes operation factor.	Make use of welding and handling most common procedures including mechanisation and automation to minimise production costs. Carry out a basic calculation of a simple welding operation	Appraise with limited autonomy a given welded fabrication case study, exemplifying welding and handling procedures that would reduce the cost of welding.	2

4.10 Repair Welding

Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	2	2	1	1
Scope:	P3	P3	P3	P3
Welding repair procedure specification……	X	X	X	X
Welding repair plan……	X	X	X	X
Welding repair procedure qualification……	X	X	X	X
NDT of the weld repair……	X	X	X	X
Special precautions……	X	X	X	X

4.10 Repair Welding – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**

IWE & IWT	Apply understanding of the problems of repair welding both for in-manufacture and in-service situations.	Demonstrate advanced knowledge and skills in the application of repair welding.	6	Explain in detail how a repair weld may detrimentally affect the quality or performance of the product. Interpret the hazards presented by repair welding, particularly for in-service repairs. Interpret comprehensive procedures to be applied to weld repairs	Make procedures for welder qualification to be applied to repair welds.	Appraise a given weld repair case study, define the procedure and welder qualification requirements. Monitor the safety requirements applications, and predict any impact on weld quality.	4
IWS & IWP	Apply basic knowledge of the problems of repair welding both for in manufacture and in-service situations.	Demonstrate basic theoretical knowledge and practical skills in the application of repair welding.	4	Outline the most common problems of making repair welds. Describe the hazards likely to occur in making repair welds particularly for in-service repairs.	Apply the most common requirements of comprehensive procedures to weld repair. Review procedural and operator qualifications to be applied to repair welds.	Appraise with limited autonomy a given weld repair case study, identifying the correct procedure and welder qualification requirements. Appraise with limited autonomy a given weld repair case study, explaining the relevant safety requirements and likely impacts on weld quality.	2

4.11 Reinforcing-steel welded joints				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	2	1	1	0
Scope:	P3	P3	P3	-
Reinforcing-steel types, properties ……	X	X	X	-
Direct and indirect loading ……	X	X	X	-
Types of joints used (lap, cruciform) ……	X	X	X	-
Calculation……	X	X	X	-
Weldability with respect to weld joint strength……	X	X	X	-
Preheating in respect to bar diameter ……	X	X	X	-
Application of welding processes ……	X	X	X	-
Standards and specifications (ISO 17660 series and National Standards)	X	X	X	-

4.11 - Reinforcing-steel welded joints – LEARNING OUTCOMES							
	ACTIONS/ ACHIEVEMENTS	**PERFORMANCE CRITERIA**	**EQF Level**	**KNOWLEDGE APPLICATION**	**PRACTICAL APPLICATION**	**COMPETENCES**	**WL**
IWE	Apply understanding of the principles of choice of joints and their design.	Demonstrate highly specialised knowledge and skills in controlling the	7	Interpret the design features of types of welded joint used for reinforcing steel in load bearing and non-load bearing locations.	Calculate the length of weld with respect to diameter.	Appraise a given reinforcing steel fabrication case study, define the	4

		welding of reinforcing steel joints			Determine the required pre-heating temperature.	type of joint and appropriate welding process. Determine the joint length, and the preheat required.	
IWT	Apply understanding of the principles of choice of joints and their design.	Demonstrate advanced knowledge and skills in controlling the welding of reinforcing steel joints	6	Explain the types of welded joint used for reinforcing steel in load bearing and non-load bearing locations.	Calculate the length of weld with respect to diameter. Determine the preheating requirements for specified joints	Appraise a given reinforcing steel fabrication case study, decide the appropriate welding process for the type and length of joint, and define the preheat temperature required.	1,5
IWS	Apply understanding of the principles of choice of joints and their design.	Demonstrate specialised knowledge and skills in controlling the welding of reinforcing steel joints	5	Associate the types of welded joint used for reinforcing steel in load bearing and non-load bearing locations. Identify methods to determine the length of weld with respect to diameter.	Check the correct application of preheat.	Appraise a given reinforcing steel fabrication case study, explain the application of welding and preheating for the joint type, length and welding process given.	1,5
IWP	NOT APPLICABLE						

4.12 Case Studies				
Objective for IWE, IWT and IWS: To understand and be able to handle welding related tasks in respect of the manufacture of specific welded products. The best way to give this education is a combination of experts from industry presenting special cases and project work to the students split up into groups, followed by a general discussion and comments by the experts. All of the following subjects have to be dealt with, the depth to which, however, will depend on the national needs.				
Qualification	**IWE**	**IWT**	**IWS**	**IWP**
Teaching hours	40	28	14	0
Scope:	P3	P3	P3	
Steel and lightweight structures, boilers and pressure vessels, chemical plants and pipelines, shipbuilding and offshore applications, transportation (automobiles, railways), aerospace applications. Common items to be covered: Standards and specifications, design, Choice of materials, welding processes, Site welding (transport and final assembly), Consumables, welding procedures, Tolerances on weld preparation and fit-up, Post weld heat treatment, NDT and quality control, Visual Inspection practice (interpretation and evaluation of fractures and welds including interpretation of fracture tests of fillet welds)	X	X	X	-
Learning Outcomes: Not Applicable				

Module 4 – Fabrication, applications engineering

Module 4	**IWE**		**IWT**		**IWS**		**IWP**	
	MT	**P1 ***	**MT**	**P1 ***	**MT**	**P1 ***	**MT**	**P1 ***
Teaching Hours	**116**	**0**	**83**	**0**	**56**	**0**	**29**	**0**

***** P1 = Part 1, Figures under P1 are given for the Standard Route (see 4.1)

I.2 Theoretical Education - IWS 0

The module IWS 0 aims at teaching basic technical knowledge, which in general is lacking in participants entering via the route 3 when compared to participants entering via routes 1 and 2. It provides the chance for professional workers and International Welding Practitioners to become qualified as International Welding Specialists

The module IWS 0 deals with the following subjects:

	Practical Training	**Teaching hours:**
0.1	Basic Metrology applicable to Welding	4
0.2	Technical Calculation	8
0.3	Technical Drawings	8
0.4	Basics of Electro-technology	2
0.5	Basics of Chemistry	2
0.6	Basics of Materials	2
0.7	Metal Products	2
0.8	Machining of Materials	2
0.9	Technical Mechanics	4
0.10	Joining Elements	2
0.11	Calculation of strength	4
		40

0.1 Basic Metrology applicable to Welding (4 hours)

Objectives: To guarantee a basic knowledge of metrology for an IWS to be able to control the quality in welding operations. To acquire a working knowledge of the metric system of measurements, i.e. the International System of Units (SI), related to welding.

Scope:

- Introduction to the metrology (basic concepts of metrology; necessity of standards for comparison; basic methods of measurement: measurement by indication, measurement by comparison; calibration standards: of mass, of length, etc);
- Basic knowledge on the metric system of measurements (International System of Units - SI).
- SI units for length, area, volume, mass, time, electrical current, voltage, energy and power, force, frequency, pressure, linear speed, acceleration, temperature, heat, plane angle, and other, as well as their derivatives commonly used in welding.
- Commonly used multiplication factors, prefixes and their symbols.
- Basic instruments for linear measurement (rulers, tape measures, sliding calipers, micrometers, etc.);
- Other instruments of measurement (protractors, pressure gauges, flow meters, etc.);
- Patterns (for comparison): angle patterns, plate thicknesses patterns, etc.
- Practical exercises.

Learning Outcomes:

1. Understand objectives of the metrology.
2. List all SI base units and their symbols for length, mass, time, electric current, voltage, temperature, plane angle and other commonly used units related to welding.
3. List all SI derived units and their symbols for area, density, energy, force, frequency, power, pressure, volume, linear velocity, and other commonly used units related to welding.
4. List commonly used multiplication factors, prefixes and their symbols.

5. Know basic instruments for linear measurement.
6. Describe patterns and give some examples of their applications.
7. List and describe measuring instruments used in welding (except those used for electrical measurements which are dealt in the Item 0.4).

0.2 Technical Calculation (8 hours)

Objectives: To demonstrate how to make calculations related to welding involving various combinations of mathematical operations, powers, square roots, basic trigonometric functions, equations, variables including linear and angular measurements and time.

Scope:

- Simple mathematical operations such as addition, subtraction, multiplication, division, powers, square roots, percentage calculation, rule of three (transposition);
- Rearranging and solving of linear equations;
- Calculation of length, area and volume;
- Conversions between Metric and Imperial systems for the length, speed and gas flow rate units (Conversion tables);
- Conversions of the temperature value between Kelvin, Centigrade e Fahrenheit systems (Conversion tables);
- Calculation of the speed and acceleration;
- Trigonometric functions;
- Use of calculators for arithmetic operations and for trigonometric functions;
- Exercises for calculations involved in welding technology (gas flow rate, wire feed speed, welding travel, welding energy, mechanical resistance of materials, fusion and deposition rates, weld bead section and volume, material cost per weld linear unit or per welding time unit, etc.)

Learning Outcomes:

1. Show examples of mathematical operations of addition, subtraction, multiplication and division of whole numbers of different signs, decimals and fractions.
2. Show examples of powers of 0, 1, 2, …. of a number including 10.
3. Show examples of square roots of numbers greater than 1 and less than 1.
4. Show examples of linear equations and how the equations can be re-arranged, manipulated and solved.
5. Explain the definition of basic trigonometric functions of sine, cosine and tangent in terms of the ratios of the sides of a right-angled triangle.
6. Be able to calculate length, area, volume, speed and acceleration.
7. Be able to use conversion tables “Metric versus Imperial system” for the length, speed and gas flow rate units.
8. Be able to use conversion tables “Temperature value between Kelvin, Centigrade e Fahrenheit systems”.
9. Show calculations related to welding involving various combinations of mathematical operations, powers, square roots, basic trigonometric functions and equations.
10. Show the use of pocket calculators for the above calculations and functions.

0.3 Technical Drawings (8 hours)

Objectives: To be able to read and understand basic technical drawings related to welding technology.

Scope:

- Introduction to the technical drawing.
- Purpose and importance of the technical drawing for the welding applications;
- Types of technical drawings (Detail Drawing, Assembly Drawing);
- Elaboration and presentation of technical drawings (sketch and final technical drawing);
- Projection views (orthographic projections: front, top, side; isometric);
- Scales;
- Types of lines (visible object line, hidden object line, center line, dimension line, …);
- Sectional views, hatching;
- Symbols on the drawings;
- Drawing of different types of diagrams;
- Practical exercises.

Learning Outcomes:

1. Explain the purpose and importance of the technical drawing for the welding applications.
2. Know how to elaborate and present a technical drawing.
3. Know projection views.
4. Explain the use and indication of scales in engineering drawings.
5. Illustrate the various types of lines and their usage.
6. Explain sectioning symbols and methods and illustrate different sectional views.
7. Know how to draw different types of diagrams.

0.4 Basics of Electro-technology (2 hours)

Objectives: To acquire a basic knowledge of the industrial electricity in relation to the requirements of welding technology.

Scope:

- Electricity generation and distribution;
- Direct current (DC) and alternating current (AC);
- Single-phase supply;
- Three-phase supply;
- Star (Y) connection;
- Delta (Δ) connection;
- Circuits, connection diagram;
- Voltmeters, ammeters, ohmmeters and multi-meters used in welding;
- Lab exercises.

Learning Outcomes:

1. Briefly describe sources of electricity.
2. Describe the major differences between DC and AC current and give examples of their individual applications.
3. Describe the 50(60)-Hz alternating current and its sinusoidal waveform.
4. Describe single-phase and 3-phase AC power lines.
5. Define peak value, mean value and RMS value for either AC current or voltage.
6. Describe a star (Y) connection.
7. Describe a delta (Δ) connection.
8. Explain the working of voltmeters, ammeter, ohmmeters and multi-meters including digital multi-meters, and their applications related to welding.
9. Read connection diagrams and simple circuits.

0.5 Basics of Chemistry (2 hours)

Objectives: To acquire a basic knowledge of chemistry for the understanding of chemical reactions in welding processes, casting processes and chemical analysis of welds.

Scope:

- Principal chemical elements and their symbols (found in steels, aluminium alloys, nickel, copper and other materials used in welding);
- Simple reactions of reduction and oxidation (used in steel manufacturing, corrosion and combustion);
- Presentation of chemical composition of gases (by volume) and of solids (by mass);
- Chemical composition of the plain carbon, low alloy and high alloy steels (tables).

Learning Outcomes:

1. List basic chemical elements and their symbols in engineering steel, aluminium, nickel and copper, and their alloys.
2. Explain chemical reaction and its representation by the chemical equation with examples of chemical reactions in steel manufacturing.
3. Briefly explain the presentation of chemical composition of gases (by volume) and of solids (by mass).
4. List the various types of plain carbon, low alloy and high alloy steels, and their chemical compositions.

0.6 Basics of Materials (2 hours)

Objectives: To be informed about main metallic materials used in welding. To know how they are classified according to their main physical properties, and how they influence material applications.

Scope:

- Description, chemical and mechanical characteristics and application of the main metallic materials: structural steels, rail steel, sheet steels, pipe steels, steels for bars and wires, spring steels, steels for easy metal-working, steels for cementation and for nitriding, tool and die steels, wear-resistant steels, corrosion-resistant steels, hot-work steels, steels to be used for the electric and magnet purposes, high strength steels, cryogenic steels, white and grey cast irons, malleable cast iron, aluminium and its alloys, copper and its alloys (brass and bronze); method of the carbon content recognition in the steel by the grinding.

Learning Outcomes:

1. Description, application, types, physical properties of main metallic materials.
2. Know the difference between the main properties of steel, cast iron, aluminium and copper.
3. List types of steels for different applications.

0.7 Metal products (2 hours)

Objectives: To know different product form in which the metallic materials used in welding are commercially supplied and to have notions about methods of their production.

Scope:

- Different product form, denominations and commercial dimensions of wrought products (plates, flat profiles, rounds, hexagonal profile, angel bars, H and U-girders, round, square and rectangular pipes);
- General description of main methods to produce plates, profiles, pipes and girders (casting, forging, lamination, extrusion and welding).

Learning Outcomes:

1. List the main types of wrought products.
2. Recognize the different wrought products and know the correct terms.
3. Explain why the different properties are dependent on the wrought production method.
4. Be able to identify materials by their designation.

0.8 Machining of Materials (2 hours)

Objectives: To be informed about the different methods to machine metals, ferrous and non ferrous alloys

Scope:

- Fundamentals of metal machining methods: cutting and abrasive tools;
- Main methods of metal machining using cutting tools (drilling, turning machining, planning machining, milling, sawing, etc.);
- Mechanical cutting using abrasive tools;
- Selection of emery, cutting and trimming discs in function of the material and of the piece form.

Learning Outcomes:

1. Know the most important machining methods.
2. Be able to describe the difference between cutting and abrasive machining.
3. List main abrasive methods.
4. List the most important cutting methods.
5. Select emery, cutting and trimming discs in function of the material and of the piece form.

0.9 Technical Mechanics (4 hours)

Objectives: To be able to make simple calculations of the forces found in welding activities.

Scope:
- Definition of force, practical examples of forces and units of force;
- Simple splitting of the force (in function of the angle) and addition of forces within a system of coordinates (practical examples: inclined plane, load lifting, etc.);
- Bending moments and torsional moment (practical examples: moment arm and winch - pulley);
- Static systems (reactions of forces and equilibrium conditions);
- Practical exercises.

Learning Outcomes:
1. Graphically splitting of forces.
2. Find the resultant force from more forces through one point.
3. Determine simple bending moments and bending forces.
4. Calculate support forces (reactions).

0.10 Joining elements (2 hours)

Objectives: To know different types of non-welding joining of different materials and transfer force particularities for those joints.

Scope:
- Dismantling joining types in comparison with welding (non dismantling one);
- Screw joining;
- Riveting;
- Adhesive bonding;
- Transmission fastening elements (e.g., pins, keys, guiding link, etc.).

Learning Outcomes:
1. List different types of material joining.
2. Make a comparison of dismantling joining types versus welding (non dismantling one).
3. Know the difference between static and transmission joints.

0.11 Calculation of Strength (4 hours)

Objectives:
Understand the difference between static mechanics and strength of materials. Knows what data can be determined during a tensile test. Recognise the different kinds of girders.

Scope:
- Elongation, deflections
- Areas of complex cross sections
- Moment of inertia, section modulus
- Stress calculation
- Stability of pieces
- Different cross sections
- Bending of girders and frames

Learning Outcomes:
1. Able to draw a tensile test diagram.
2. Able to explain the tensile test diagram.
3. Calculate/verify tension.
4. Calculate section modulus.
5. Calculate moment of inertia.
6. Calculate cross section area.

Total **40 hours**

I.3. Practical Education – Part 2

I.3.1 For the IWE; IWT, and IWS

This part does not aim at providing practical skills to the welding engineer/technologist/specialist but on gaining knowledge on the control of the different welding processes. The students shall become as familiar as possible with the problems and typical defects associated with incorrect use of the different welding methods. During their exercises the students are guided by skilled welding teachers.

Practical Training	**hours:**
Oxygas welding and cutting	6
MMA	8
TIG	8
MIG/MAG + Flux Cored Arc Welding	16

It is possible to use the advantages of Virtual Weld Training systems but maximum to 50% of the practical training hours!

	hours:
Demonstration or video presentations of processes	22
Gouging	
Brazing	
Plasma welding	
Plasma cutting	
Submerged-arc welding	
Resistance welding	
Friction welding	
Electron beam welding	
Laser welding	
Other processes	
Total:	60

It is strongly recommended that ATBs provide demonstrations instead of videos wherever possible.

Candidates may be exempted by the ATB from the practical training, on a process by process basis, if they can demonstrate practical experience and/or training in the process concerned.

The laboratory exercises contained in the foregoing modules 1 to 4 of the theoretical part are additional and given usually at a later stage of the education.

I.3.2 For the IWP

The practical training has to be done on an individual basis.

The main processes are: MMA, MIG/MAG, FCAW, TIG and Gas Welding. 40 hours shall be reserved to broaden the student's skill in other relevant materials within his welder qualification/s. This training shall end with a practical examination in more than one process or more than one group of materials (according ISO 9606 or national standards). For MIG welding only material group 22 and for Gas welding only material groups 1.1 and 1.2 are relevant.

If a student can demonstrate existing practical skill in and an understanding of the welding of different materials, it is accepted that he can sit for the practical examination in these processes and materials without prior practical training.

Typical test pieces and positions are given in Table 1. The test pieces shall be welded as single side welding without backing, except for aluminium, where backing is allowed. Each ANB will work to a similar table based on comparable national standards.

Valid national certificates are accepted as replacements for the practical examinations with test pieces in Table 1.

Table 1: Recommended test pieces and positions for practical examinations:
The dimensions given in the table are recommended/proposed, but not mandatory, other dimensions are accepted.

Welding process		Practical Test		
ISO 9606	**ISO 9606**	**Material Group (ISO TR 15608)**	**Welding Position**	**Test Dimension(s) Diameter/Thickness**
MMA	111	1	PF/BW	6,0 – 13,0
		3	PF/BW	6,0 – 13,0
		4, 5, 6	H-L045/BW	∅60,3 – ∅114.3/ 3.9 – 7.11
		7	PF/BW	6,0 – 13,0
		8	PB/FW	6,0 – 13,0
TIG	141	1	H-L045/BW	∅60,3 – ∅114.3 3.9 – 7.11
		3	PF/BW	2,0 – 6,0
		4, 5, 6	H-L045/BW	∅60,3 – ∅114.3 3.9 – 7.11
		7	PF/BW	2,0 – 6,0
		8	H-L045/BW	∅60,3 – ∅114.3 3.9 – 7.11
		22	PF/BW	2,0 – 6,0
MIG	131	22	PF/BW	6,0 – 13,0
MAG (and/or metal cored)	135 (136)	1	PF/BW	6,0 – 13,0
		8	PB/FW	6,0 – 13,0
FCAW (flux cored only)	136	1	PF/BW	6,0 – 13,0
		8	PF/BW	6,0 – 13,0
		3	PA/FW	6,0 – 13,0
GAS	311	1	H-L045/BW	∅60,3 – ∅114.3 3.9 – 7.11

Twenty hours shall be reserved to give the student basic understanding of the possibilities and limitations of the other processes mentioned in Table 1. The purpose of this training is only to demonstrate the possibilities and limitations of these processes, and no practical examination is required. If the student can demonstrate to the training establishment skill in and understanding of the other processes, he may be exempted from this training.

Acceptance criteria for the practical examination:

The quality of welding shall comply with ISO 9606, or comparable quality levels defined in National welders' qualification standards used by IAB Group A countries. A welder qualification certificate may be issued.

Section II: Examination and Qualification

Note: Other rules/procedures are covered in Document IAB-001- (see latest edition).

1. Introduction

This guideline seeks to achieve international harmonisation and a common standard in the examination and qualification of professional welding engineers, technologists, specialists and practitioners. The national welding organisations, being members of the IIW/EWF, mutually acknowledge the Diplomas awarded in any Member Country to International Welding Engineers, Technologists, Specialists and Practitioners, following examination conducted in accordance with this Guideline.

Education must have followed this IIW guideline and the examination must have been conducted by the Authorised Nominated Body.

2. Approval of Training Courses

Any training course leading to the examination must be approved by the ANB. The number of teachers required to give the course shall be sufficient to ensure that the essential specialist knowledge and industrial experience to cover the syllabus are adequately represented in the team of teachers and visiting lecturers.

3. Examination Board

An Examination Board, acting on behalf of the ANB supervises the ANB National part of the examination process. In this way, independence, integrity and fairness of the examination system are maintained.

4. Admission to the Examination

Admission to the examination leading to the award of the International Welding Engineer, Technologist, Specialist and Practitioner diploma will be restricted to those:

b) Who comply with the minimum requirements specified in the directory of access conditions, and
c) Standard Route: Who have attended at least 90% of the course (Exemptions are at the discretion of the ANB), approved by the ANB, according to this guideline., or
d) Who have attended a Distance Learning Course approved by the ANB fulfilling the requirements of guideline IAB-195-see latest edition, or
e) Alternative Route: Who have successfully passed the ANB detailed assessment (see diagram 9)

5. Examination procedures

This guideline defines the minimum requirements for examinations. ANBs are free to exceed these if they wish.

The examination procedures described below are designed to test the candidate's knowledge and understanding of different situations in welding technology. There will be written and oral examinations (where applicable) in each of the following modules (held either on completion of each Module of the syllabus or at the end of the course):

a) Welding processes and equipment
b) Materials and their behaviour during welding
c) Construction and design
d) Fabrication and applications engineering

The final examination has to cover all training parts (1 to 3).

All ANBs shall apply the harmonised examination system as a part of the total time allocated by the ANB written examination. This shall be done according to OP-17.
Both written and oral examinations, where applicable, may be held either on completion of each Module of the syllabus or at the end of the course.

5.1 Written examination

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

a) A series of essay questions covering the whole field of the module
or
b) A series of multiple choice questions covering the whole field of the module
or
c) A combination of a) and b)

The time devoted to the written examination shall be a minimum of:
IWE level – 2.0 hours per module, i.e. 8 hours in all.
IWT level – 1.5 hours per module, i.e. 6 hours in all.
IWS level – 1.0 hour per module, i.e. 4 hours in all.
IWP level – 2.0 hours in total for the four modules

The duration of the harmonised examination is always a part of the total time above mentioned for each qualification level.

The harmonised exam matrix and duration is defined for each IIW qualification level according to OP – 17. The harmonised exams are automatically generated by the IIW harmonised exam management software.

All questions that are active in the IIW harmonised examination database have been evaluated and approved by the IIW appointed Experts.

The ANB's Examination Board has no active task in terms of exam development, generation and scoring of the harmonised exams.

Note: For the time being the ANB has the option to take into account the results of the harmonised examination or ignore them when reaching a decision about the candidate's overall results.

5.2 Oral Examination

When an oral examination is required it shall take place after the written module examination(s) have been concluded. The oral examination is designed to test understanding and ability to reason in the field of welding.

Oral examination is only mandatory for the IWE level, but at the discretion of the Examination Board IWE Candidates may be granted exemption from oral examination in any module in which they achieved >75% of the maximum possible mark in the written examination. For the other levels of training the oral examination will be optional at the discretion of the Examination Board.
In the borderline cases (to be defined by the ANB) oral examination shall be recommended.

For the IWE level the total time devoted to the oral examination, covering all four modules, shall be a minimum of 1 hour per candidate.

5.3 Practical examination

The practical examination is only applied for the IWP qualification level. It shall be implemented as described in section I, item 3.2.

5.4 Intermediate examination

An intermediate examination is only necessary if the courses are carried out in three separate parts (1 to 3).
The intermediate examination is mandatory for access Route 2 and it is the responsibility of the Authorised National Body (ANB) to ensure that those entering by this Route 2 have achieved the required knowledge of Part 1 to enter Part 3 of the course.

At the discretion of the ANB the intermediate examination shall consist of:

a) A series of essay questions covering the whole field of Part 1 of the modules or
b) A series of multiple-choice questions covering the whole field of Part 1 of the modules or
c) A combination of a) and b)

The time devoted to the intermediate examination shall be a minimum of:

IWE level – 1.0 hour
IWT level – 1.0 hour
IWS level – 30 minutes
IWP level – 30 minutes

Failure in the intermediate examination shall require re-examination. Examinations can be retaken after 24 hours minimum. Failure in a second re-examination will require the student to enter Part 1 of the course.

5.5 Resources to be used in examinations except harmonised examinations

Programmable calculators, smartphones, tablet PC's, formulary, course material, etc. are allowed to be used only at the discretion of the Board of Examiners.

6. Evaluation of Performance

Written and oral examinations shall usually have equal importance (50%), but the weight of the oral examination may, at the discretion of the Board of Examiners, be set anywhere within the range of 40% to 60%. The weighting of the oral examination shall be announced before the start of the examination.

In order to pass the examination candidates shall achieve at least

60% of the maximum possible mark in each module examination

The final decision has to be given by the chairman of the Board of Examiners.

The examination in all four modules shall be completed within a period of 6 years from the date of the first (modular) examination.

7. Re-examination

Failure in any individual module of the examination shall require re-examination only in the module failed.
If a candidate fails in any of the 4 modules three times, they must retake the classes of the modules failed and the full examination of the module failed.

8. Appeals Procedure

Candidates who feel they have been unfairly treated during the examination procedure have the right to appeal to the Authorised National Body.

9. International Welding Diploma's

After successful examination, a diploma is awarded to the candidate by the Authorised National Body.

10. Transition Arrangements

All National Transition Arrangements are published on the IAB Transition Arrangements Directory, doc. IAB-021- (see latest edition).

Each country's specific Transition Arrangements are approved by the IAB Group B and may be obtained from each Authorised National Body.
An ANB can offer Transitional Arrangements with indefinite closing date according to the Rules IAB-001, paragraph 1.12 – latest edition

Practising Welding Engineers, Technologists, Specialists and Practitioners will be eligible for the award of the International Welding Engineer, Technologist, Specialist and Practitioner Diploma, if they can demonstrate to the ANB that their combination of education, training and experience in welding technology has provided a level of knowledge equivalent to the current IAB requirements and if they fulfil the ANB requirements defined in the Transition Arrangement Directory.

Two additional general rules shall be observed when applying the Transitional Arrangements:

1. Applicants shall possess the basic qualification and experience defined in relevant guideline and in the Access Condition Directory, Doc. IAB-020- (see latest edition) -..
2. Diplomas may be awarded under Transitional Arrangements in the following cases:

   a) by the ANB in the country in which the applicant received his/her welding qualification OR
   b) by the ANB in the country in which the applicant is currently practising, in contact with the ANB of the country in which the original qualification was issued.

Appendix I: Requirements for equipment, facilities and specimens for the International Welding Engineer (IWE), Technologist (IWT), Specialist (IWS) and Practitioner (IWP) course leading to the award of IIW qualification

1. Equipment

The following equipment shall be in good working order and fit for its purpose:

1.1 Welding equipment

Equipment for the following processes shall be available for practical exercises.

Manual metal arc welding	111
MIG welding	131
MAG welding	135/136/138
TIG welding	14
Gas welding	311
Gas flame cutting	81

Further processes covered by the syllabus may be shown by means of demonstrations or video presentations.

1.2 Other equipment

Mechanical testing, metallurgical examination and NDT equipment shall be available for both demonstration and laboratory work purposes.

2. Specimens

A reference collection of well documented weld specimens, polished and etched, should. reflect the processes covered by the Guideline and one specimen per process is required (at minimum for the most common welding processes – see syllabus item 1.2 to 1.12.1; recommended is to show all other processes by means of slides, photos, etc.). Preferably the specimens should cover a number of materials and thicknesses.

Appendix II: Abbreviations for Processes

The following abbreviations used in the document show the relation between the ISO designation, the process abbreviations used in Europe and those used in the USA.

ISO 4063	European (EA) and American (AA) abbreviations		Full name
111	EA	MMA	Manual Metal Arc Welding
	AA	SMAW	Shielded Metal Arc Welding
114	EA	FCAW	Self-shielded tubular cored arc
	AA	FCAW	Self-shielded tubular cored arc welding
12	EA	SAW	Submerged Arc Welding
	AA	SAW	Submerged Arc Welding
13	EA	GMAW	Gas Shielded Metal Arc Welding
	AA	GMAW	Gas Metal Arc Welding
131	EA	MIG	MIG welding with solid wire electrode
	AA	GMAW	Gas metal arc welding using inert gas and solid wire electrode
132	EA	MIG	MIG welding with flux cored electrode
	AA	FCAW	Flux cored arc welding
135	EA	MAG	MAG welding with solid wire electrode
	AA	GMAW	Gas metal arc welding using active gas with solid wire electrode
136	EA	MAG	MAG welding with flux cored electrode
	AA	FCAW	Gas metal arc welding using active gas and flux cored electrode
138	EA	MAG	MAG welding with metal cored electrode
	AA	FCAW	Gas metal arc welding using active gas and metal cored electrode
141	EA	TIG	TIG welding with solid filler material (wire/rod)
	AA	GTAW	Gas tungsten arc welding using inert gas and solid filler material (wire/rod)
142	EA	TIG	Autogenous TIG welding
	AA	GTAW	Autogenous gas tungstenarc weldingusing inert gas
21	EA		Resistance spot welding
	AA	RSW	Spot Welding
25	EA		Resistance Butt Welding
	AA	RSEW	Upset Welding
3	EA		Gas Welding
	AA	OFW	Oxy-fuel Gas Welding
311	EA		Oxy-acetylene Welding
	AA	OAW	Oxy-acetylene Welding

ISO 4063	European (EA) and American (AA) abbreviations		Full name
42	EA	FW	Friction Welding
	AA	FW	Friction Welding
43	EA	FSW	Friction Stir Welding
	AA	FSW	Friction Stir Welding
81	EA		Flame Cutting
	AA	OFC	Oxygen Cutting, oxyfuel cutting
86	EA		Flame Gouging
	AA		Thermal Gouging

Appendix III: Requirements for ANB Detailed Assessment used in Alternatives Routes

After the candidate has fulfilled the requirements of the ANB paper check he will be admitted to the ANB Detailed Assessment (Diagram 9).

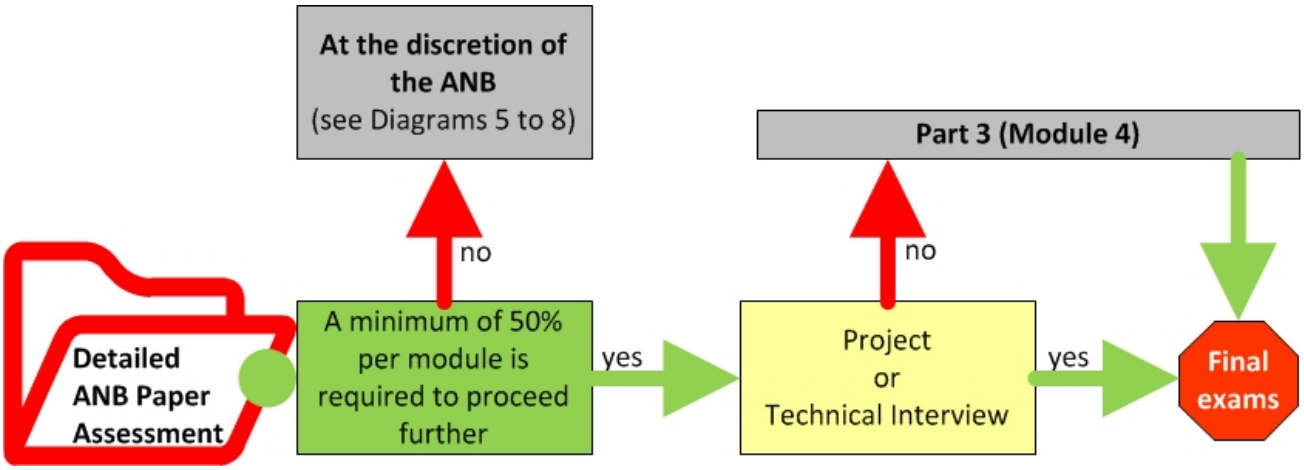

Diagram 9: ANB detailed Assessment

The ANB detailed assessment shall include:

a) a detailed paper assessment of the candidate's CV for evidence of that the candidates knowledge of the subject matter in guidelines 1 to 4 is consistent with the relevant qualification level. This is achieved using a check list with point allocations

b) a project or a technical interview to test the candidate's ability to logically apply the knowledge expected by the relevant qualification guideline in module 4 (Fabrication, applications engineering).

The sequence of this assessment shall be determined by the ANB. It is within the discretion of the ANB to terminate the assessment at any point and defer the application or re-direct the candidate to the standard route.

The paper assessment shall be based on a review of the applicant's experience and education against the IIW guideline and access conditions. This review will be based on the information provided by the applicant, as outlined in his/her Curriculum Vitae and in supporting documentation which may include course outline, transcripts, certification documents, diplomas, degrees, etc.

a) The **detailed paper assessment** shall be done with the following point system:

Modules	**Frames of requirements** (max. number of points) **for:**	
	IWE and IWT	**IWS and IWP**
Module 1: Welding processes and equipment	22	22
Module 2: Materials and their behaviour during welding	21	15
Module 3: Construction and design	19	11
Module 4: Fabrication and applications engineering	22	20
Sum:	84	68

Detailed distribution of points for Modules 1, 2, 3 and 4

Module 1: Welding processes and equipment	Max. number of points		
	IWE and IWT	IWS	IWP
111 - MMA	3	3	4
14 - TIG and 15 - Plasma	2	2	2
131 - MIG	2	2	2
135 - MAG	2	2	2
114, 136 and 138 - Flux-cored methods	3	3	3
91, 93 and 97 - Brazing methods	2	2	0
81, 82 and 83 - Thermal cutting	2	2	3
12 - SAW	3	3	3
Other methods	3	3	3
Sum:	22	22	22

Module 2: Materials (acc. to ISO/TR 15608) and their behaviour during welding		Max. number of points		
		IWE and IWT	IWS	IWP
Steel alloys	groups 1 – 3 and 11	4	4	6
Cr-Mo- and vanadium steels:	groups 4 - 6	2	1	1
Ferritic and martensitic steels	group 7	3	2	2
Austenitic and aust./fer. steels	groups 8 and 10	4	2	3
Steel-Ni- alloys, max 10% Ni	group 9	1	1	1
Aluminium and alloys	groups 21 - 26	3	2	2
Copper and alloys	groups 31 - 38	1	1	0
Nickel and alloys	groups 41 - 48	1	1	0
Ti, Zr and alloys	groups 51 – 54 and 61 - 62	1	0	0
Cast iron	groups 71 - 76	1	1	0
Sum:		21	15	15

Module 3: Construction and design	Max. number of points		
	IWE and IWT	IWS	IWP
Stresses and strains	5	2	0
Design of welded structures - static loading	3	3	4
Design of welded structures - dynamic loading	3	1	2
Joint design & design principles of welded structures	4	4	5
Design of structures of aluminium and its alloys	4	1	0
Sum:	19	11	11

Module 4: Fabrication and applications engineering	Max. number of points	
	IWE and IWT	IWS and IWP
Quality assurance in welded fabrication	4	3
Quality control during manufacture	3	3
Welding stresses and distortion	4	4
Plant facilities, welding jigs and fixtures	2	2
NDT	3	3
Economics	2	1
Health and safety	2	2
Repair welding	2	2
Sum:	22	20

As a minimum, the applicant shall reach 50% in each module to be admitted to the project or technical inter-view.

Note: If an applicant has a certification at the relevant level which covers a module the ANB may accept this as equivalent to the required 50% level.

Welder Qualification Certificate (for IWP candidate only)

A minimum of two valid welder qualification certificates corresponding with Section I, Chapter 6 of the standard route shall demonstrate in common with the paper assessment.

b) Project or Technical Interview

At the discretion of the ANB, the candidate shall:

- complete a project, which includes a practical application, and provide a final report and discussion;
  or
- be assessed via a technical interview.

Each of these assessment routes are explained below.

b.1) Project

The project shall be in form of a case study. The purpose of the project is to evaluate the candidate's ability to apply knowledge in the area of Fabrication, applications engineering (module 4). The project should be of sufficient complexity and detail that the typical time allocated for completion meets the requirements set out in the table below. Once started the project should be completed within a maximum period of time which is also shown in the table below.

At the discretion of the ANB the case study may be performed as a group exercise. Each candidate shall, however, prepare a final report and presentation (b.1-3 below) individually.

Time conditions	Qualification level			
	IWE	IWT	IWS	IWP
Time allocated time for project completion	80 hours	60 hours	40 hours	8 hours
Maximum period in which the project should be completed.	4 weeks	3 weeks	3 weeks	1 week

The ANB shall decide on the choice of project construction and the applicable codes and/or product standards. One of the following type of construction shall be taken:

Type of construction	Qualification level			
	IWE	IWT	IWS	IWP
Pressure vessel	X	X	X	X
Construction – static loading	X	X	X	X
Construction – dynamic loading	X	X	X	
Other construction	X	X	X	X

Alternatively, the ANB may, at its discretion, accept a proposal for a project from the candidate based on the candidate's field of work. In such a case the project shall meet allocated time and maximum period requirements mentioned above.

The project work is detailed as following:

b.1 - 1 Pre-study	IWE	IWT	IWS	IWP
• Pre-study including a workmanship example.	-	-	-	X
• Understand the consequences of the desired manufacturing code.	X	X	X	-
• Evaluation of drawings and technical specifications.	X	X	-	-
• Read and understand drawings and technical specifications.	-	-	X	X
• Evaluation of and comments to the choice of base materials. Discuss the weldability of the materials. Any needs for pre- and post-weld heating.	X	X	-	-
• Knowledge about the choice of base materials. Discuss the weldability of the materials. Any needs for pre- and post-weld heating.	-	-	X	X
• Evaluation of the construction based on the choice of:	X	X	X	
• Discussion of the construction based on the choice of:	-	-	-	X
– Joining method(s) for the base material(s);	X	X	X	X
– Cutting method(s) for preparation of base material parts;	X	X	X	X
– Joint preparation and weld calculation;	X	X	X	-
– Joint preparation;	-	-	-	X
– Welding consumables;	X	X	X	X
– Need of surface treatment before welding;	X	X	X	X
– Surface treatment of finished construction - method(s) to be used.	X	X	-	-
• Preparation of necessary WPSs and testing methods.	X	X	X	-
• Interpretation of necessary WPSs.	-	-	-	X
• Evaluation of necessary welding qualification(s) for welder(s).	X	X	X	-
• Interpretation of necessary welding qualification test(s) for welder(s).	-	-	-	X
• Present NDT methods to be used during and after welding.	X	X	X	-
• Discuss possible NDT methods that can be used during and after welding, including special tests to check the entire quality of the construction.	-	-	-	X
• Prepare:				
– Production plan;	X	X	X	-
– Welding plan – including welding sequence and tack welding;	X	X	X	-
– List of standards needed for the project;	X	X	-	-
– Quality plan for the production based on relevant part of ISO 3834 or equivalent. Type of workshop for this kind of production shall be discussed.	X	X	X	-

b.1 - 2 Practical part on the construction or on test pieces – simulating the same construction – provided by the ANB	IWE	IWT	IWS	IWP
• Checking:				
– Marking(s) and certificate(s) on base material(s);	X	X	X	X
– Welder(s) qualification test certificate(s);	X	X	X	X
– Qualification of personnel for destructive testing, NDT and inspection.	X	X	X	-
• Evaluation of test results and compare with pre-study figures.	X	X	X	-
• Plan for inspection before and during welding.	X	X	X	-
• Inspection after welding based on pre-study plans – (visual inspection and other NDT methods, eventually pressure testing or other testing methods).	X	X	X	-
• Discussion of inspection reports.	-	-	-	X
• Evaluation of the welding and test results based on inspection and NDT reports.	X	X	X	-
• If evaluation shows need for repair, plan(s) for repair welding and eventually WPSs for repair welding to be made.	X	X	X	-
• Evaluation of fabrication costs.	X	-	-	-

b.1 - 3 Final report and presentation	IWE	IWT	IWS	IWP
• The candidate shall prepare a final written report with results from his project based on the pre-study figures and the practical part.	X	X	X	-
• The report shall include viewpoints regarding economy of production and at same time ensure the quality of the product.	X	X	X	-
• The candidate shall give an oral presentation of the project to the board of examiners.	X	X	X	-
• The candidate shall give an oral report of results from his project based on the pre-study figures and the practical part.	-	-	-	X

b.2) Technical Interview

Technical Interview:

Technical Interview duration is at least:			
IWE level	**IWT level**	**IWS level**	**IWP level**
6 hours	4 hours	3 hours	2 hours

The Technical Interview will be divided in 2 parts, they are:

i) Applicant discussion regarding Part 1 – Evaluation of the Knowledge (see table below)

ii) Applicant discussion regarding Part 2 – Evaluation of Practical knowledge (see table below)

Before the Technical Interview the candidate shall be allowed at least 1 hour to become acquainted with the documentation that will be used during the interview. The interview should normally be completed face to face. At the discretion of the ANB the interview may be conducted remotely using a computer based visual interview package provided that the interview process is secure and examination conditions can be maintained.

The ANB shall supply the applicant with a set of documents (construction drawings - part of a construction, list of materials, materials certificates, NDT reports, destructive testing reports, WPQRs, WPSs, Welder Approvals).

Or

The applicant may present to the ANB a set of documents (construction drawings - part of a construction, list of materials, materials certificates, NDT reports, destructive testing reports, WPQRs, WPSs, Welder's Approvals). The documents should be from the company where the applicant is currently employed. The ANB shall review the documentation provided by the candidate before confirming that it is suitable and acceptable for use in the Technical Interview.

The technical interview shall address at least the subjects mentioned on the tables below.

i) Part 1 - Evaluation of the Knowledge

b.2 - 1 Discussion of the Construction	**IWE**	**IWT**	**IWS**	**IWP**
• Evaluation of drawings and technical specifications.	X	X	-	-
• Read and understand drawings and technical specifications.	-	-	X	X
• Evaluation of and comments to the choice of base materials. Discuss the weldability of the materials. Any needs for pre- and post-weld heating.	X	X	-	-
• Knowledge about the choice of base materials. Discuss the weldability of the materials. Any needs for pre- and post-weld heating.	-	-	X	X
• Evaluation of the construction based on the choice of:	X	X	X	-
• Discussion of the construction based on the choice of:	-	-	-	X
– Joining method(s) for the base material(s);	X	X	X	X
– Cutting method(s) for preparation of base material parts;	X	X	X	X
– Joint preparation and weld calculation;	X	X	X	-
– Joint preparation;	-	-	-	X
– Welding consumables;	X	X	X	X
– Need of surface treatment before welding;	X	X	X	X
– Surface treatment of finished construction - method(s) to be used.	X	X	-	-
• Preparation of necessary WPSs and testing methods.	X	X	X	-
• Interpretation of necessary WPSs.	-	-	-	X
• Evaluation of necessary welding qualification(s) for welder(s).	X	X	X	-
• Interpretation of necessary welding qualification test(s) for welder(s).	-	-	-	X
• Present NDT methods to be used during and after welding.	X	X	X	-
• Discuss possible NDT methods that can be used during and after welding, including special tests to check the entire quality of the construction.	-	-	-	X
• Discussion of the construction in terms of:	-	-	-	-
– Welding plan – including welding sequence and tack welding;	X	X	X	-
– Standards needed for the project;	X	X	-	-
– Quality plan for the production based on relevant part of ISO 3834 or equivalent. Type of workshop for this kind of production shall be discussed.	X	X	X	-
– Jigs, fixtures, welding equipment	X	X	X	X

ii) Part 2 – Practical discussion

b.2 – 2 Practical Part	IWE	IWT	IWS	IWP
• Checking:				
– Certificate(s) on base material(s);	X	X	X	X
– Welder(s) qualification test certificate(s);	X	X	X	X
– Qualification of personnel for destructive testing, NDT and inspection.	X	X	X	-
– Welding Procedure Qualification Record - WPQR;	X	X	X	-
– Welding Procedure Specification - WPSs;	X	X	X	X
• Evaluation of test results and discussion of the reports.	X	X	X	-
• Proposal for a Plan for inspection before, during and after welding and discussion.	X	X	X	-
• Discussion of inspection reports.	-	-	-	X
• Evaluation of the welding and test results based on inspection and NDT reports.	X	X	X	-
• Welds needing for repair, plan(s) for repair welding and eventually WPSs for repair welding to be made.	X	X	X	-
• Brief discussion on fabrication costs.	X	-	-	-

When the ANB has confirmed that the candidate has met the requirements of the detailed paper assessment and the project or technical interview process, he/she is admitted to the final examination defined for the relevant guideline.

Appendix IV: List of Referenced Standards

Standard (-series)	Title
ASME IX	American Society of Mechanical Engineers; Boiler and Pressure Vessel Code, Section IX: Welding and Brazing Qualifications
ISO/TR 581	Weldability – Metallic Materials, Definitions
ISO/TR 17671-1 (EN 1011-1)	Welding - Recommendations for welding of metallic materials - Part 1: General guidance for arc welding
ISO/TR 17671-2 (EN 1011-2)	Welding - Recommendations for welding of metallic materials - Part 2: Arc welding of ferritic steels
ISO 17639	Destructive tests on welds in metallic materials - Macroscopic and microscopic examination of welds
ISO 14732	Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials
EN 1708	Welding - Basic weld joint details in steel (series)
ISO 2553	Welded, brazed and soldered joints - Symbolic representation on drawings
ISO 3834	Quality requirements for fusion welding of metallic materials (series)
ISO 4063	Welding and allied processes - Nomenclature of processes and reference numbers
ISO 5817	Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections
ISO 9000	Quality management systems (series)
ISO 9606	Approval testing of welders - Fusion welding (series)
ISO 9692	Welding and allied processes - Recommendation for joint preparation (series)
ISO 9712	Non-destructive testing - Qualification and certification of personnel
ISO 10042	Welding - Arc-welded joints in aluminium and its alloys - Quality levels for imperfections
ISO 17635	Non-destructive examination of welds - General rules for metallic materials
ISO 13916	Welding - Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature
ISO 13920	Welding - General tolerances for welded constructions - Dimensions for lengths and angles - Shape and position
ISO 14731	Welding coordination - Tasks and responsibilities
ISO/TR 15135	Welding - Design and non-destructive testing of welds
ISO/TR 15235	Welding - Methods for assessing imperfections in metallic structures

Standard (-series)	Title
ISO/TR 15481	Welding of reinforcing steel - Tack weldability - Test methods and performance requirements
ISO 15607	Specification and qualification of welding procedures for metallic materials - General rules
ISO/TR 15608	Welding - Guidelines for a metallic material grouping system
ISO 15609	Specification and qualification of welding procedures for metallic materials – Welding procedure specification (series)
ISO 15610	Specification and qualification of welding procedures for metallic materials - Qualification based on tested welding consumables
ISO 15611	Specification and qualification of welding procedures for metallic materials - Qualification based on previous welding experience
ISO 15612	Specification and qualification of welding procedures for metallic materials - Qualification by adoption of a standard welding procedure
ISO 15613	Specification and qualification of welding procedures for metallic materials - Qualification based on pre-production welding test
ISO 15614	Specification and qualification of welding procedures for metallic materials - Welding procedure test (series)
ISO/TR 16060	Destructive tests on welds in metallic materials — Etchants for macroscopic and microscopic examination
ISO 17660	Welding - Welding of Reinforcing Steel (series)
ISO 17662	Welding - Calibration, verification and validation of equipment used for welding, including ancillary activities
ISO 17663	Welding - Guidelines for quality requirements for heat treatment in connection with welding and allied processes