IIW Guideline

INTERNATIONAL WELDING INSPECTION PERSONNEL

Minimum Requirements for the Education, Examination and Qualification

IAB-041r4-16

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

INTERNATIONAL WELDING INSPECTION PERSONNEL

(IWIP)

International Welding Inspector Level Comprehensive (IWI-C)

International Welding Inspector Level Standard (IWI-S)

International Welding Inspector Level Basic (IWI-B)

Guideline of the International Institute of Welding

INTERNATIONAL AUTHORISATION BOARD

Prepared and issued by the IAB-International Authorisation Board
based on the EWF Guideline EWF-450
Under the authority of the IIW-International Institute of Welding

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Preface

This document is based upon the European Welding Inspection Personnel Guideline (former Document EWF-450) as developed by the European Federation for Welding, Joining and Cutting (EWF), through an Agreement first signed in 19 July 1997 at the Annual Meeting of the International Institute of Welding in San Francisco, California, USA and which has been renewed and further developed since then.

Any EWF ANB is permitted to issue EWF diplomas equivalent to the IIW ones that have been issued by the same ANB.

Copies of this document are available from the IIW IAB Secretariat or their designated distributor.

MINIMUM REQUIREMENTS FOR THE EDUCATION, TRAINING AND QUALIFICATION OF INTERNATIONAL WELDING INSPECTION PERSONNEL (IWIP)

1. Introduction and scope

This Guideline covers education, training and qualification of Welding Inspection Personnel. It does not cover Certification of these personnel.

This Guideline is designed to provide the core education and training in welding and inspection technology required by those responsible for performing inspection tasks at various levels. It is possible that additional training and/or experience may be necessary beyond the core education and training to meet the requirements of specific applications or job functions or local requirements or legislation.

Section 1 of this Guideline covers the minimum requirements for education and training, agreed upon by all national welding societies within the IIW, in terms of objectives, scope, learning outcomes and teaching hours to be devoted to achieving them. These will be revised periodically by IIW IAB Group A to take into account any changes that may affect the “state of the art”. Students having successfully completed this course of education and training will be expected to be capable of applying welding inspection technology as covered by this Guideline.

Section 2 of this document covers rules for examination and qualification.

2. Definitions and acronyms

For the scope of this Guideline, the following definitions apply:

- **Education and training:** A process of instruction in relevant theory and practice that takes the form of courses of an approved syllabus and periods of practical work under qualified supervision (but shall not include the use of specimens used in the practical examination). All educational courses leading to the award of qualification covered by this Guidelineshall be approved by the IIW Authorised Nominated Body (ANB).
- **Qualification**: A demonstration in accordance with the IIW Guidelines and rules, conducted by the Authorised Nominated Body, involving an examination of the knowledge and skill related to specified criteria. Success in this examination leads to the issue of the related IIW diploma gained. Such diplomas remain valid for the lifetime of the holder.
- **Relevant inspection experience:** The period during which the candidate performed welding inspection as his/her main activity under qualified supervision including personal application of inspection to materials, parts or structures.

In the scope of this Guideline, the following acronyms are used for the inspection personnel:

- **IWIP:** International Welding Inspection Personnel qualified according to this Guideline;
- **IWI-C:** International Welding Inspector at the Comprehensive level;
- **IWI-S:** International Welding Inspector at the Standard level;
- **IWI-B:** International Welding Inspector at the Basic level;

In the scope of this Guideline, the following acronyms are used for the education and training modules:

- **WT-C:** Welding Technology education and training, Comprehensive Level
- **WT-S:** Welding Technology education and training, Standard Level
- **WT-B:** Welding Technology education and training, Basic Level
- **WI-C:** Welding Inspection education and training, Comprehensive Level
- **WI-S:** Welding Inspection education and training, Standard Level

- **WI-B:** Welding Inspection education and training, Basic Level

In the scope of this Guideline, the following acronyms are used for the examinations:
- **WTE-C** Welding Technology Exam, Comprehensive Level
- **WTE-S** Welding Technology Exam, Standard Level
- **WTE-B** Welding Technology Exam, Basic Level
- **WIE-C** Welding Inspection Exam, Comprehensive Level
- **WIE-S** Welding Inspection Exam, Standard Level
- **WIE-B** Welding Inspection Exam, Basic Level
- **PE-C** Practical Exam, Comprehensive Level
- **PE-S** Practical Exam, Standard Level
- **PE-B** Practical Exam, Basic Level
- **IWS 0** Examination as related to IWS 0 training, see Doc. IAB 252 in its last revision

3. The Inspector's role

The inspector's role begins well before welding starts, continues during the welding operation, involves action after welding is completed, and is finalised only when the results are properly reported. As part of the quality system, inspection activities are defined in an inspection and test plan, which clearly describes what is required. The inspector is frequently responsible for producing documents that ensure traceability of the components and related fabricating action.

Prior to welding, the inspector must be assured that the materials are correct and that the shop has approved welding procedures and appropriately qualified welders. Written procedures and competent operators are important to the production of a quality welded product, but the actual execution of the weld is also a critical point for the inspector. Once the inspector is satisfied that all is in order for the welding to proceed, the task becomes one of witnessing and monitoring. There are two basic interests at this point: ensuring that the written procedures are being followed; and checking for any physical signs of non-conformance of the final product.

The inspector's responsibilities are to verify base metals and welding consumables, observe the fit-up and preparation for the weld, and watch the welding operation itself. Once the welding is completed, a new series of inspection tasks begin, which start with executing an inspection programme according to an approved procedure, maintaining the status of examination and testing and selecting specific welds for further NDT or mechanical testing.

Heat treatment (such as preheating, post-heating and post-weld heat treatment) can be a critical parameter in a welding operation and the inspector is often required to ensure that it has been done properly. Heat treatment must be carried out following an approved written procedure. The inspector must know enough about the technique, the equipment and the reports to have confidence in the results.

3.1 Reports

When preparation, production and inspection are over, the inspector must collate the observations, checklists, and results into a report that is structured to meet the needs of the client, a jurisdiction, or a code. This report is the document of reference, which could allow the tracing of a production parameter that proves after years of service to be contributing to a failure. It allows the tracing of responsibility to a specific supplier or contractor.

One or more interim reports might well be necessary to show progress during a long or complicated construction project. Reports must detail the inspection stages, parameters, and results, including corrective actions if required. It is important to identify quality related problems as early as possible. Interim reports and observations are extremely valuable as they provide engineering and production personnel with information they might not otherwise be aware of. The

inspector's observations might highlight quality problems that could, perhaps, be remedied by design or production changes if found early enough. The inspector should remember to quantify observations where possible.

Typical duties of a welding inspector amomgst others, are as follows:

1) Interpretation of drawings and specifications;
2) Verification of procedure (WPS) and welder or welding operator qualifications;
3) Verification of the application of approved welding procedures;
4) Selection of production test samples;
5) Interpretation of test results;
6) Preparation of reports and keeping of records;
7) Preparation of inspection procedures; and
8) Check the correct application of NDT methods.

The authority to stop work or call for immediate remedial action to resolve a quality problem is particularly important in defining the responsibility of the inspector.

4. Levels of Inspection Personnel

This gGuideline sets out the education and training for three levels of welding inspection personnel personnel, as follows:

4.1 BASIC (IWI-B): A candidate completing the "Basic" level of training under this programme shall possess a general knowledge of welding and inspection application and theory. This knowledge base will enable the candidate to effectively perform the following tasks:

- Conduct direct unaided visual inspection to identify and evaluate welding imperfection according to acceptance criteria;
- Verify, witness and understand all welding related activities in fabrication, including (but not limited to) the following points:
  - Verify the adequacy of information on NDT reports (VT, PT, MT, RT, UT) for conventional techniques;
  - Verify data and adequacy of material certificates (base and filler materials);
  - Verify identification and treacability of the materials during the fabrication process;
  - Verify the compliance of raw materials and consumables against the applicable standards, codes and specifications;
  - Verify the implementation of the WPS in production for conventional applications (*e.g. arc welding processes, steels - see Section 1 for detailed information*);
  - Verify the implementation of PWHT specifications in production;
  - Witness welder approval tests including testing of the specimens or test coupons;
  - Witness production test coupons;
- Read and understand an Inspection Testing Plan;
- Read and understand the construction drawings in relation to inspection activities; and
- Report any of the above actions to a qualified supervisor.

4.2 STANDARD (IWI-S): A candidate completing the "Standard" level of training under this programme shall possess an advanced knowledge of welding and inspection theory and application. This knowledge base will enable the candidate to perform the following tasks (in addition to the IWI-B):

- Supervise the activities of the IWI-B;
- Develop and provide instructions to IWI-B;
- Develop, comment and review Quality Control Plans and Inspection and Testing Plans based on product standards, codes, specifications, drawings and regulatory requirements;
- Witness procedure qualification tests including testing of the specimens;

- Verify the compliance of WQPRs and WPSs and welder qualifications and approvals against the applicable standards, codes and specifications for conventional applications *(e.g. arc welding processes, steels, aluminium alloys - see Section 1 for detailed information)*;
- Verify the compliance of PWHT specifications against the applicable standards, codes and specifications;
- Verify the compliance of raw materials and consumables certificates against the applicable standards, codes and specifications;
- Take decisions on acceptance of quality documents related to welding fabrication (e.g NDT, material testing, production testing, etc.);
- Take decisions based on quality documents (e.g NDT, material testing, production testing, etc.) according to the requirements defined for the construction;
- Verify radiographic films quality adequacy (no interpretation);
- Identify and verify the relevant NDT techniques for a welded construction; and
- Report on all the above actions.

4.3 COMPREHENSIVE (IWI-C): A candidate completing the "Comprehensive" level of training under this programme shall possess an intimate knowledge of welding and inspection theory and application. This knowledge base will enable the candidate to perform the following tasks (in addition to the IWI-S and IWI-B):

- Manage the whole of the Welding Inspection activities;
- Supervise the activities of the IWI-S and IWI-B;
- Develop and provide instructions to IWI-S and IWI-B;
- Act as a technical expert for the Inspection function;
- Develop, comment and review Quality Control Plans and Inspection Testing Plans for applications not covered by product standards, codes, specifications, drawings and regulatory requirements; and
- Manage inspection activities for non-conventional applications with reference to materials, processes, and advanced destructive testing and NDT techniques *(see Section 1 for detailed information).*

5. Routes to Qualification

Three distinct routes to gaining the qualifications described in this document have been agreed:
1. the Standard Route;
2. the Alternative Route; and
3. Distance Learning Programs (see IAB-195 in its last revision).

It is also recognised that personnel certified for NDT at levels 1, 2 or 3 may be exempted from part of the training, see paragraph 8.

6. Standard Routes to Qualification

This Guideline provides different routes to qualification, based on different acccess conditions and experience as follows.

6.1 Routes to qualification to IWI-C

Route 1 This route is for those fulfilling the national standard access conditions for IWT or higher, as defined in the directory of access conditions, doc. IAB 020 in its last revision. To gain the qualification, candidates should attend the education and training and pass the relevant exams as reported in Table 1 with the exception that candidates may decide on the basis of prior learning and/or experience and subject to an ATB assessment and authorisation to proceed directly to the Welding Technology Exams (WTE-S and WTE-C); only in this case, passing the WT exams is required before

entering the Welding Inspection Education and Training Courses (WI-B, WI-S and WI-C).
At the discretion of the ANB, and only for students attending the full standard courses education and training, the Welding Technology Exams (WTE-S and WTE-C) can be performed on the same day as the Welding Inspection Exams (WIE-S and WIE-C) and the Practical Exams (PE-S and PE-C). Route 1 is represented in figure 1.

Route 2 This route is for those already holding an existing IIW qualification as International Welding Technologist or higher who may proceed directly to the Welding Inspection Modules at the relevant level. In this case, it is not required that applicants are subject to WT examinations at the relevant level. Route 2 is represented in figure 1.

Route 3 This Guideline considers a system for career development for those qualified IWI-S who have gained two years of relevant inspection experience at IWI-S level to progress to IWI-C (without complying with the access condition given in route 1) only attending WT-C and WI-C training and passing relevant Welding Technology, Inspection and Practical Exams (WTE-C, WIE-C and PE-C) via Route 3 as shown in figure 2.

Candidates may decide, on the basis of prior learning and/or experience and subject to an ATB assessment and authorisation, whether to take the Welding Technology Module (WT-C) first, or proceed directly to the Welding Technology Exam (WTE-C); only in this case, passing the exam is required before entering the Welding Inspection Module (WI-C).

At the discretion of the ANB, and only for students attending the full standard courses education and training, the Welding Technology Exam (WTE-C) can be taken on the same day of the Welding Inspection Exam (WIE-C) and the Practical exam (PE-C). Route 3 is represented in figure 2.

6.2 Routes to qualification to IWI-S

Route 1 This route is for those fulfilling the national standard access conditions for IWS/EWS as defined in the directory of access conditions., doc. IAB 020 in its latest revision, Route 1 and 2, without any limitation in age or experience. To gain the IWI-S qualification, candidates should attend the education and training and pass the relevant exams as reported in table 1, with the exception that candidates may decide on the basis of prior learning and/or experience and subject to an ATB assessment and authorisation to proceed directly to the Welding Technology Exam (WTE-S); only in this case, passing the WT exams (WTE-S) is required before entering the Welding Inspection Education and Training Courses (WI-B and WI-S).
At the discretion of the ANB, and only for students attending the full standard courses education and training, the Welding Technology Exam (WTE-S) can be performed on the same day as the Welding Inspection Exam (WIE-S) and the Practical Exam (PE-S). Route 1 is represented in figure 2.

Route 2 This route is for those already holding an existing IIW qualification as International Welding Specialist (or higher) who may proceed direct to the Welding Inspection Module at the relevant level. In this case it is not required that applicants are subject to WT examination (WTE-S). Route 2 is represented in figure 1.

Route 3 This Guideline considers a system for career development for those qualified to IWI-B who have gained two years of relevant inspection experience at IWI-S level, to progress to IWI-S (without complying with the access condition given in route 1) by only attending WT-S and WI-S education and training and passing relevant Welding Technology, Inspection and Practical Exams (WTE-S, WIE-S and PE-S). Those entering IWI-S via

route 3 without satisfying the access condition for Route 1, have to proceed to IWS 0 training and examination, see doc. IAB 252 in its last revision, before entering the Welding Technology education and training. Route 3 is shown in figure 2.

In addition, candidates may decide on the basis of prior learning and/or experience and subject to an ATB assessment and authorisation, to proceed directly to the Welding Technology Exam (WTE-S); only in this case, passing the exam is required before entering the Welding Inspection Module and Practical Examinations (WIE-S and PE-S).

At the discretion of the ANB, and only for students attending the full standard courses education and training, the Welding Technology Exam (WTS-S) can be performed on the same day of the Welding Inspection Exam (WIE WIS-S) and the Practical Exam (PE-C). Route 3 is represented in figure 2.

6.3 Routes to qualification to IWI-B

Route 1 This route is applicable to persons having educational backgrounds in science or engineering, to professional workers and to those having at least two years of professional welding related experience. To gain the IWI-B qualification, candidates should attend the education and training and pass the relevant exams as reported in table 1, with the exception that candidates may decide on the basis of prior learning and/or experience and subject to an ATB assessment and authorisation to proceed directly to the Welding Technology Exam (WTE-B); only in this case, passing the WT Exams is required before entering the Welding Inspection Education and Training Course (WI-B).

At the discretion of the ANB, and only for students attending the full standard courses education and training, the Welding Technology Exam (WTE-B) can be performed on the same day as the Welding Inspection Exam (WIE-B) and the Practical Exam (PE-B). Route 1 is represented in figure 1.

Route 2 This route is for those already holding an existing IIW qualification as International Welding Practitioner or higher who may proceed direct to the Welding Inspection Module at the relevant level. In this case it is not required that applicants are subject to WT examination at the relevant level. Route 2 is represented in figure 1.

6.4 General rules for all standard routes

For all Routes, if the candidate fails the Welding Technology Examination twice at the appropriate level, having exercised an option to proceed directly to that examination, he/she must take the omitted training module before resitting the failed examination.

Rules for IWS 0 are reported in doc. IAB 252, in its last revision.

The rules for the conduct of the examinations by the IIW Authorised Nominated Body (ANB) are prescribed in Section 2 of this Guideline.

Level	Education and training		Examinations (route 1)		
	Welding technology (*)	**Welding inspection**	**Welding technology**	**Welding inspection**	**Practical**
IWI-C	WT-B (47h) + WT-S (30h) + WT-C (26h) **Total: 103h**	WI-B (55h) + WI-S (43h) + WI-C (32h) **Total: 130h**	WTE-C + WTE-S + WTE-B	WIE-C + WIE-S + WIE-B	PE-C + PE-S
IWI-S	WT-B (47h) + WT-S (30h) **Total: 77h**	WI-B (55h) + WI-S (43h) **Total: 98h**	WTE-S + WTE-B	WIE-S + WIE-B	PE-S
IWI-B	WT-B (47h) **Total: 47h**	WI-B (55h) **Total: 55h**	WTE-B	WIE-B	PE-B
(*) Subject to an ATB assessment, the Welding Technology exams can be skipped at the appropriate level before entering Welding Inspection education and training.					

Table 1 – Standard routes for qualification for IWIP, Route 1

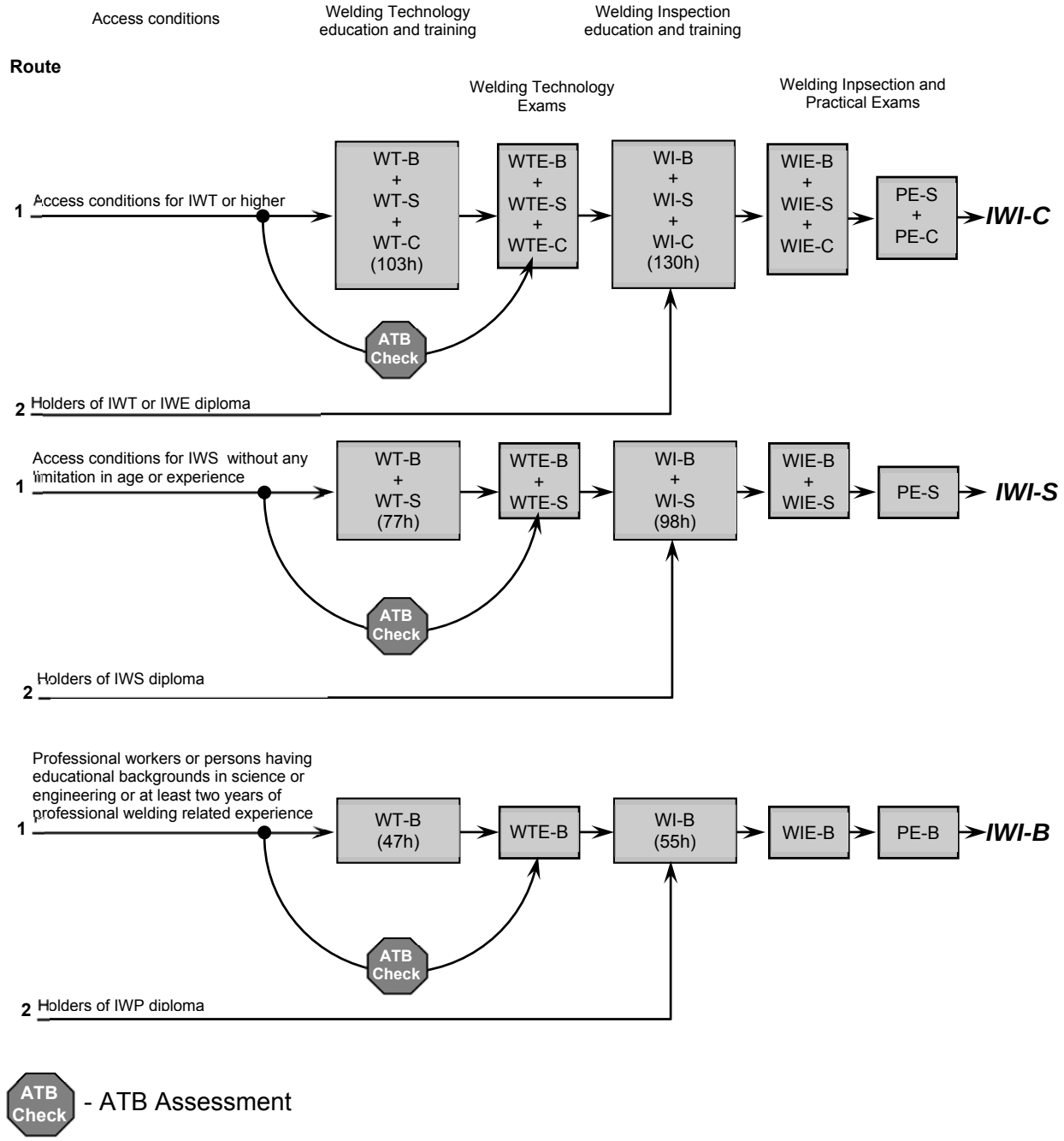
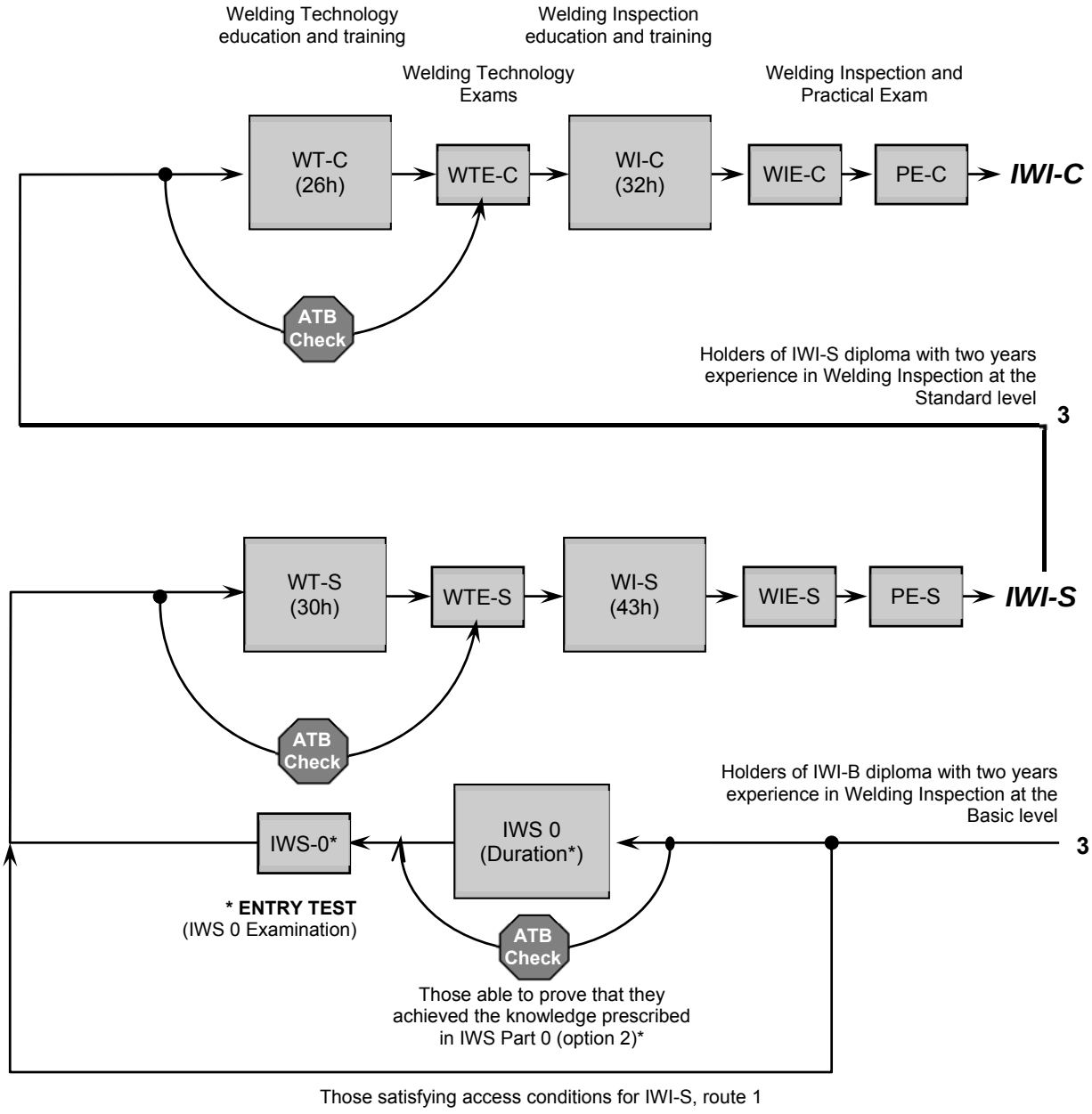


Figure 1. Standard Routes 1 and 2
(The diagram has the only scope to show routes to qualification, see text for requirements)



ATB Check - ATB Assessments

* See doc. IAB 252r1, last revision

Figure 2. Standard Route 3
(The diagram has the only scope to show route 3 to qualification, see text for requirements)

7. Alternative routes to qualification

To gain qualification according to the Alternative Route, applicants shall submit an application form to the ANB together with the documents indicated in paragraphs 5.1 to 5.3 for a paper assessment.

The ANB shall conduct a paper assessment to ensure that the applicant meets the Access Conditions for the Alternative Route (see the list of access conditions, doc IAB 020 in its last revision) and evaluate the applicant's practice and related job function in welding inspection. The result of this assessment shall determine if the applicant is suitable for further detailed assessment (see Appendix II).

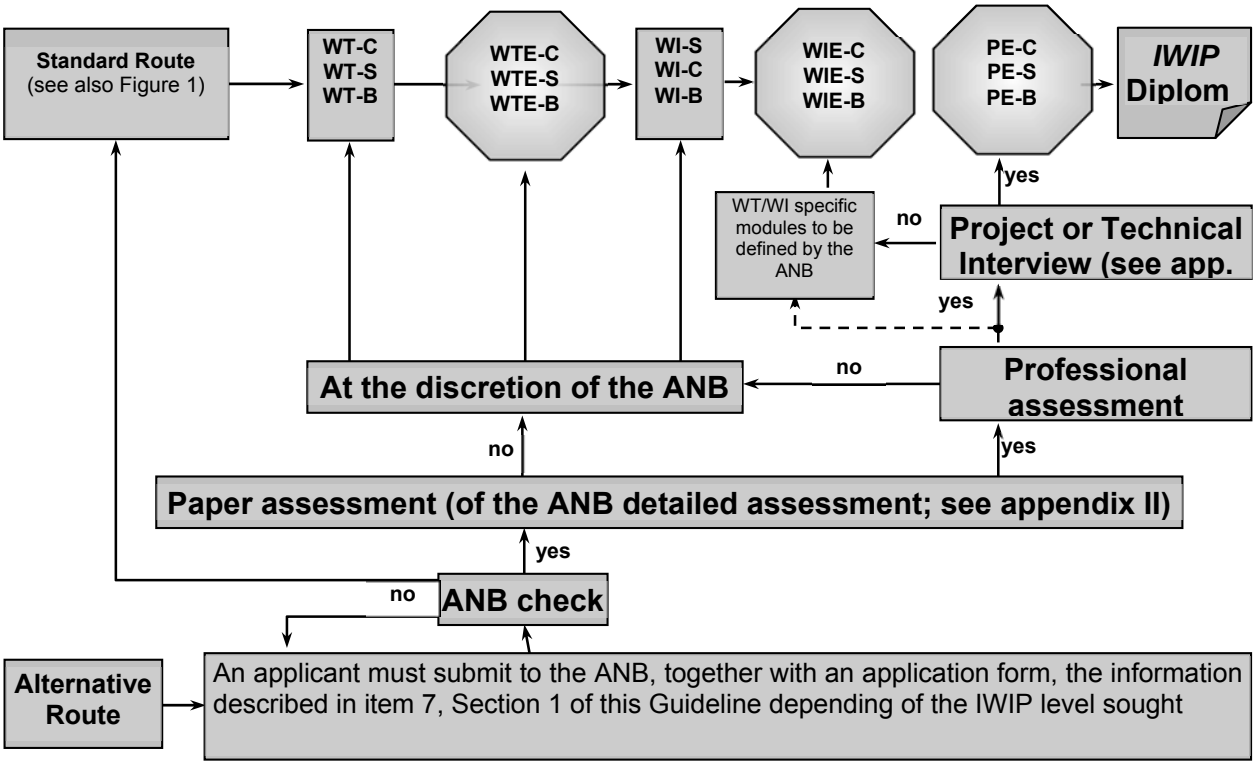


Figure 3. Alternative versus Standard Routes for IWIP qualifications

7.1 Qualification to IWI-C

- IWT diploma or evidence of satisfying the access conditions for IWT or higher.
- A curriculum vitae (CV)/resume containing the following professional information:
  - Evidence of at least three years job function in welding and inspection at the Comprehensive level (in a period of 4 years before application)
  - A justification of the candidate's experience, training, and education to become IWI-C (may include other test results)

7.2 Qualification to IWI-S

- IWS diploma or evidence of satisfying the access conditions for IWS or higher.
- A curriculum vitae (CV)/resume containing the following professional information:
  - Evidence of at least two years job function in welding and inspection at the Standard level (in a period of 3 years before application)
  - A justification of the candidate's experience, training, and education to become IWI-S (may include other test results)

7.3 Qualification to IWI-B

- IWP diploma or evidence of satisfying the access conditions defined for the IWI-B for Route 1 or higher.
- A curriculum vitae (CV)/resume containing professional information:
  - Evidence that the candidate was working in welding and inspection at the Basic level during the last two years before application
  - A justification of the candidate's experience, training, and education to become IWI-B (may include other test results)

The ANB shall determine, by paper check, if the application is suitable for further detailed assessment.

8. Recognition of NDT certification

Those having certification in NDT in accordance with ISO 9712, or equivalent recognised by the ANB may be granted exemption from the NDT parts of the modules for Welding Inspection on a method by method basis, but not from the final examination. The approval of such arrangements is at the discretion of the ANB.

It is recommended that exemption for NDT Level 2 or 3 Certifications should apply to Modules WI-S and C; exemptions for NDT Level 1 certifications should apply to Module WI-B.

Section 1 - Theoretical and practical education and training, Module welding technology and welding inspection: syllabus and performance objectives

All topics in the modules must be covered; however, the sequence may be varied.

Theoretical Education: Welding Technology Modules

	Number of Course Hours in Modules		
	WT-C	WT-S	WT-B
Module 1. Welding processes and equipment (hours)	**13**	**5**	**17**

1.1 General introduction to welding technology:			
Objectives for IWI-B: *Understand the difference between welding processes, and to be familiarized with terminology, standards and abbreviations.*			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**1**
History			x
Most common definitions and terminology			x
Schematic presentation of welding processes			x
General applications for welding			x
Abbreviations used for most common welding and cutting processes (fusion arc and flame)			x
Overview of the most common welding and cutting processes (fusion arc and flame)			x
Classification of welding processes (IIW, ISO, CEN and national standards)			x
Difference between manual, mechanized and automatic welding			x
Learning Outcomes for IWI-B			
1. Recognise processes with reference to the classification reported in standards.			
2. Outline the major differences between each main type of welding process, e.g. fusion arc, resistance, and flame.			
3. Designate a welding process by its common abbreviation.			

1.2 Oxy-gas welding and related processes:			
Objectives for IWI-B: Recognise the fundamentals of oxy-gas combustion, characteristics of the different fuel gases, equipment, safety and typical applications.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope / **Teaching hours**	**0**	**0**	**1**
Process principles			X
Range of application			X
Types of flames			X
Fuel gases (e.g. acetylene, propane)			X
Equipment			X
Handling and storage of gases			X
Typical joint design for welding			X
Methods of welding techniques, rightward, leftward			X
Standards for filler materials			X
Welding applications, typical problems and imperfections			X
Learning Outcomes for IWI-B			
1. Recognise the characteristics of the different types of flames and their application in welding.			
2. Identify the limitations and the range of application of the process.			
3. Understand given standards for consumable classification.			

1.3The Arc and Power Sources for Arc Welding			
Objective for IWI-B: To recognsie an electric arc, its characteristics, limitations and application in welding and to Gain a basic working knowledge on arc welding power sources characteristics and components.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope / **Teaching hours**	**0**	**0**	**1**
Arc physics (i.e. producing an electric arc, the main arc areas, stability of the arc)			X
Influence of the magnetic fields on the arc (why, how to solve)			X
Power source classification, types and characteristics (including inverters)			X
Power source electrical characteristics (static and dynamic)			X
Relationship between static characteristic and welding process			X
Stability of processes in AC and DC			X
Open circuit voltage, short circuit current			X
Voltage losses, relationship between welding current value and cable section			X
Learning Outcomes for IWI-B			
1. Outline the arc stability of DC and AC.			
2. Outline the influence of magnetic fields on an electric arc.			
3. Give examples of solving magnetic deflection problems.			
4. Recognise for each type of arc welding power source the static characteristics.			
5. Outline the meaning of open circuit voltage, arc voltage, short circuit current, voltage losses, and current to cable section relationship.			

1.4Tungsten inert gas arc welding

Objective IWI-S: To gain an understanding of TIG welding of non ferrous alloys fundamentals, including equipment, applications, procedures and specific problems.

Objective IWI-B: To gain a general outline of TIG welding of steel fundamentals, including equipment, and applications and common problems.

Module / Scope / Teaching hours	WT-C	WT-S	WT-B
	0	1	2
Power source characteristics			X
Methods for arc ignition and necessary equipment			X
Equipment and accessories: torches, gas lens, control panel, up and down slope, pulse techniques			X
Effect of current type and polarity: DC(+), DC(-) and AC		X	X
Specific requirements for different materials, e.g. aluminium		X	
Consumables: shielding gases, filler materials, electrodes			X
Welding parameters: current, voltage, travel speed, gas flow rate		X	X
Joint preparation: typical joint design for welding, fit-up, cleaning		X	X
Welding procedures and techniques		X	X
Special techniques: spot-welding, key-hole, hot-wire, orbital welding, tube to tube and tube to sheet , and others		X	
Standards for filler materials, electrodes, and gases		X	X
Welding applications, typical problems and how to solve them		X	X

Learning Outcomes for IWI-S

1. Explain the selection of appropriate current, polarity, shielding gas and electrode type according to the application.
2. Identify the appropriate procedures for welding of aluminium, including consumables and classification.
3. Give examples of special tchniques used in Tungsten Inerta Gas welding.

Learning Outcomes for IWI-B

1. Outline TIG welding including arc ignition methods and their most common applications.
2. Give examples of the most common applications for each type of current, polarity and electrode.
3. Give examples of the most important applications and select the appropriate values for welding parameters.
4. Know how to use and care for the equipment and accessories.
5. Understand given standards for consumable classification.
6. Give examples of TIG applications, joint preparation and potential problems to overcome.

1.5MIG / MAG and Flux Cored arc welding

Objectives for IWI-S: To gain a general understanding of MIG/MAG and Flux Cored Arc welding fundamentals, including equipment, applications, procedures and common problems including special techniques and wedling of non-ferrous materials.

***Objectives for* IWI-B:** To gain a general outline of MIG/MAG and Flux Cored Arc welding fundamentals, including equipment, and applications and common problems.

Module	WT-C	WT-S	WT-B
Scope / **Teaching hours**	**0**	**1**	**2**
Power source characteristics for conventional process and CPU controlled power sources			X
Effect of current type and polarity			X
Equipment and accessories: torches, wire feeders, hose assembly, control panel			X
Metal transfer modes (i.e. dip, globular, spray, and pulsed), and their application			X
Welding parameters and settings: current, voltage, travel speed, gas flow rate, etc.			X
Consumables: shielding gases, filler materials (solid and flux cored wires), and their combinations			X
Joint preparation: typical joint design for welding, fit-up, cleaning			X
Welding procedures and techniques			
Special techniques: electronically controlled transfer modes, multi wire (including welding procedures)		X	
Standards for filler materials, and gases			X
Welding applications, typical problems and how to solve them		X	X
Specific requirements for wedling of non ferrous materials		X	

Learning Outcomes for IWI-S

1. Describe the special techniques and the relevant procedures.
2. Define applicable requirements and procedures for welding of non ferrous materials.

Learning Outcomes for IWI-B

1. Describe MIG/MAG and Flux Cored Arc welding, comparing metal transfer modes and their application.
2. Identify the most common applications of each type of current, polarity and electrode.
3. Identify the most important applications and select appropriate welding parameters.
4. Know how to use and care for the equipment and accessories.
5. Understand given standards for consumable classification.
6. Give examples of MIG/MAG application range, joint preparation and potential problems to overcome.

1.6 Manual Metal arc welding

Objectives for IWI-B: To gain an general outline of MMA welding fundamentals, including equipment, applications and common problems.

Module	WT-C	WT-S	WT-B
Scope **Teaching hours**	**0**	**0**	**2**
Process principles and arc characteristics			X
Effect of current type and polarity			X
Equipment and accessories			X
Process application range and typical problems			X
Covered electrodes (functions of the coating and rod, types of electrodes)			X
Handling and storage of electrodes (storage environment, redrying			X
Electrode classification			X
Selection of covered electrodes for applications			
Welding parameters: current, voltage, run out length, etc			X
Joint preparation: typical joint design for welding, fit-up, cleaning, welding position			X
Relationship between electrode diameter and current range, rod material, electrode length and welding position			X
Welding procedures and techniques			X

Learning Outcomes for IWI-B

1. Outline MMA welding working principles, arc striking methods and their applications.
2. Outline the handling and storage of each type of consumable.
3. Give examples of the most important applications and select appropriate welding parameters.
4. Understand given standards for consumable classification
5. Give examples of MMA application range, joint preparation and potential problems to overcome.
6. Outline potential hazards and methods of safe handling and working.

1.7 Submerged-arc welding

Objectives for IWI-S: **To gain a general understanding of** *SAW welding fundamentals, including equipment, applications, procedures and specific problems.*

Objectives for IWI-B: *To gain a general outline of SAW welding fundamentals, including equipment, applications and common problems.*

Module / Scope / Teaching hours	WT-C 0	WT-S 1	WT-B 2
SAW process principles and arc characteristics			X
Effect of current type and polarity			X
Power source characteristics applicable to SAW (e.g. open circuit voltage, static and dynamic characteristics, types of current, arc striking methods)			X
Equipment and accessories			X
Process application range and typical problems			X
Consumables (i.e. functions of the flux and wire, types of flux and wire, wire-flux combination)			X
Handling and storage of consumables (e.g. storage environment, redrying)			X
Consumable classification			X
Welding parameters: current, voltage, travel speed, type of flux and particle size, stick-out, etc			X
Joint preparation: typical joint design for welding, fit-up, cleaning.			X
Welding procedures and techniques			
Single-wire			X
Multi -wire techniques (including welding procedures)		X	
Special techniques (strip-cladding, iron-powder addition, cold and hot wire addition)		X	

Learning Outcomes for IWI-S

1. Describe the principles of SAW process including arc striking methods, special techniques and their applications.
2. Describe how to the selection of appropriate type of current, polarity and consumable according to application.
3. Identify the range of application, appropriate joint preparations and potential problems to be overcome.
4. Demonstrate the use of appropriate standards.

Learning Outcomes for IWI-B

1. Outline SAW welding working principals including arc striking methods and their applications.
2. Outline the handling and storage of each type of consumable.
3. Give examples of the most important applications and select appropriate type of current, polarity and consumable according to application.
4. Give examples of SAW application, appropriate joint preparations and potential problems to be overcome.
5. Understand given standards for consumable classification.

1.8 Resistance welding			
Objectives for IWI-C: To understand resistance welding fundamentals, applications and specifications, including common problems and their solution.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**2**	**0**	**0**
Process principles and overview on types of processes (spot, projection, butt, seam, and flash)	X		
Joule effect and temperature distribution	X		
Equipment and accessories	X		
Process application range and typical problems (e.g. welding thin to thick material, welding of coated/ painted materials, welding dissimilar materials, mass effect, shunt effect, Peltier effect, resistance brazing)	X		
Electrodes (functions, types, shapes, material)	X		
Electrode classification	X		
Welding parameters: current, pressure, time, type of current, pulse, etc	X		
Joint preparation: typical joint design for welding, fit-up, cleaning	X		
Relation between welding parameters and the characteristics of the weld nugget	X		
Monitoring systems, statistical process control, measuring, etc.	X		
Specific testing	X		
Welding procedures	X		
Learning Outcomes for IWI-C			
1. Describe the principles of resistance welding and the application of the various sub-processes.			
2. Outline the selection of appropriate parameters to give sound welds.			
3. Identify the range of application, appropriate material preparation and potential problems to be overcome.			
4. Demonstrate the use of appropriate standards.			

1.9 LASER, electron beam and plasma arc welding			
Objectives for IWI-C: To understand the principles, field of application and common problems of plasma, electron beam and laser processes.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**4**	**0**	**0**
Basic principles for all mentioned processes	X		
Heat generation for each type of process	X		
Equipment and accessories for each type of process	X		
Typical process applications and problems	X		
Consumables	X		
Welding parameters for each process	X		
Joint preparation: typical joint design for welding, fit-up, cleaning	X		
Relation between welding parameters and joint configuration	X		
Comparison between high energy processes	X		
Appropriate standards for each process	X		
Learning Outcomes for IWI-C			
1. Describe the principles of the processes.			
2. Identify applications for each type of process.			
3. Identify the welding parameters, appropriate joint preparations and potential problems to be overcome for each process for a given application.			
4. Demonstrate the use of appropriate standards.			

1.10 Other welding processes			
Objectives for IWI-C: To understand the principles, field of application and common problems of electro-slag, friction; friction stir, magnetically impelled arc welding; magnetic pulse welding, ultrasonic; explosive; diffusion; aluminothermic; high-frequency; stud, cold-pressure welding, hybrid processes, etc.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**2**	**0**	**0**
Basic principles for all mentioned processes	X		
Heat generation for each type of process	X		
Equipment and accessories for each type of process	X		
Typical process applications and problems	X		
Consumables	X		
Welding parameters for each process	X		
Joint preparation: typical joint design for welding, fit-up, cleaning	X		
Appropriate standards for each process	X		
Learning Outcomes for IWI-C			
1. Describe the principles of the processes mentioned in the objective and their application.			
2. Identify applications for each type of process, and the precautions necessary to achieve a sound weld.			
3. Identify common problems for each process for a given application.			
4. Demonstrate the use of appropriate standards.			

1.11 Cutting and other edge preparation processes			
Objectives for IWI-B: To gain a general outline of the basic principles and the field of application of the most common cutting and edge preparation processes used in welded constructions, including equipment, procedures and common problems.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**2**
Survey of edge preparation processes and edge quality			X
Mechanical cutting, drilling and machining of joint edges (eg. pipes, plates).			X
Principles of flame and flame powder cutting, equipment, applications and auxiliaries			X
Flame cutting parameters, edge quality, oxygen purity grades			X
Materials suitable for flame cutting			X
Basic principles of the various arc cutting and gouging processes (air-arc, oxy-arc cutting, electrode) equipment and auxiliaries			X
Materials suitable for arc-cutting, applications, cutting parameters for each process			X
Fundamentals of plasma cutting, equipment and auxiliaries			X
Materials suitable for plasma cutting, applications, cutting parameters, cutting gases			X
Plasma cutting special applications (under water cutting, cutting with water vortex)			
Plasma gouging			X
Fundamentals of electron beam and Laser cutting, equipment, parameters, applications			
Fundamentals of water jet cutting, equipment, parameters, applications			X
Fundamentals of arc gouging and flame gouging, parameters and applications			X
Appropriate standards for each process			X
Learning Outcomes for IWI-B			
1. Outline the principles of cutting and other edge preparation processes.			
2. Identify the influence of the process on the edge surface quality.			
3. Point out the range of applications for cutting and other edge preparation processes.			

1.12 Surfacing and Spraying			
Objectives for* IWI-C*: To gain an understanding of the fundamentals and field of application of the most common surfacing and spraying techniques including equipment, procedures and common problems.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**2**	**0**	**0**
Working principles and applications for cladding techniques (e.g. rolling, explosive, strip, plasma-MIG, electroslag, laser)	X		
Working principles and applications of the spraying techniques (e.g. flame spraying with powder, flame spraying with wire, arc spraying with powder, arc spraying with wire, plasma spraying with powder, HVOF spraying)	X		
Equipment and parameters for each process and technique	X		
Surface preparation of the base material for each process and technique	X		
Applications and special problems	X		
Appropriate standards for each process	X		
Learning Outcomes for IWI-C			
1. Describe the principles and characteristics of the most common cladding techniques.			
2. Describe the principles and characteristics of the most common spraying techniques.			
3. Identify factors affecting the successful application for the most common processes and techniques.			

1.13 Fully Mechanised processes and robotics			
Objectives for IWI-C: To gain an understanding of the principle and industrial applications of welding mechanisation and the use of robotics in welding, including applications and systems.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**2**	**0**	**0**
Survey of welding mechanisation	X		
Robotics, mechanisation, and automation: difference, advantages disadvantages and applications	X		
Robotics (on line and off line programming, simulation, flexible manufacturing systems)	X		
Seam tracking, types and typical applications	X		
Arc sensing, magnetic induction, vision system	X		
Narrow gap welding (SAW, MIG/MAG, TIG)	X		
Orbital welding (MIG/MAG, TIG)	X		
Gases and filler materials (optimisation for mechanised welding).	X		
Learning Outcomes for IWI-C			
1. Describe applications in welding using robotics, automation and mechanisation.			
2. Describe the advantages and disadvantages of each type of seam tracking system.			
3. Describe the factors affecting weld quality.			
4. Identify the principle, benefits and applications of narrow gap and orbital welding.			

1.14 Brazing and soldering			
Objectives for IWI-S: To gain an outline of the fundamentals and the field of application of brazing and soldering, procedures, equipment, applications, and common problems.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**2**	**0**
Fundamentals of brazing, soldering and braze-welding (e.g. bonding mechanisms, surface tension, wetting, capillarity)		X	
Survey of applicable techniques, equipment, range of applications		X	
Consumables and fluxes, types, applications, and main functions of the fluxes		X	
Brazable materials, brazing requisites			
High vacuum brazing, brazing under controlled atmosphere		X	
Braze welding (e.g. Oxyfuel, MIG/MAG, Plasma, LASER)		X	
Soldering (i.e. dip, wave flow, vapour phase, soldering)		X	
Brazing, soldering and braze-welding: advantages and disadvantages		X	
Applications		X	
Learning Outcomes for IWI-S			
1. Outline the different techniques for brazing, soldering and braze-welding.			
2. Point out the most relevant applications for each brazing and soldering technique.			
3. Outline the influence of surface preparation in brazing and soldering techniques.			
4. Identify the types and characteristics of consumables and fluxes employed.			
5. Demonstrate the use of appropriate standards.			

1.15 Joining processes for ceramic materials			
Objectives for IWI-C: To gain an outline of the general principles of joining ceramics, including the common techniques (diffusion bonding, brazing and soldering, ultrasonic, adhesive bonding, etc.), applications, and common problems.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**1**	**0**	**0**
General information on ceramics and composites and typical joining processes	X		
General study of the operating principles for each process	X		
Advantages and disadvantages	X		
Learning Outcomes for IWI-C			
1. Describe the fundamentals of joining ceramics.			
2. Identify precautions to produce a sound joint for some advanced materials.			

1.16 Welding process demonstrations			
Objective for IWI-B: To gain a basic knowledge of the effect of parameters on weld bead shape and cut surface quality.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**4**
Practical demonstrations covering: MMA, TIG, MIG/MAG/Flux Cored arc wedling, Oxy-cutting, Air-Arc, Plasma-cutting, Arc-Cutting			X
Learning Outcomes for IWI-B:			
1. Recognise the welding and cutting processes demonstrated.			

	IWI-C	IWI-S	IWI-B
Module 2. Materials and their behaviour during welding	**11**	**20**	**19**

2.1. Structure and properties of metals and alloys			
Objectives for IWI-B: Understand the principles of solidification, deformation and recrystallisation and the characteristics of typical metal structures, focusing on mechanical properties.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**3**
Basic knowledge on the following items: Crystalline structures and types (focusing in ccc, cc and hc structures) Pure metals - Crystalline structure - Solid state transformation Alloys - Alloying elements location (Sustitutional solid solution; Interstitial solid solution; Intermetallic compounds; Chemical compounds; Pure metal (no alloyed)) - Basic types of phase diagrams (non-, fully- and partly soluble components, Eutectic and Eutectoide points). Solidification structure - Equiaxe and basaltic structures - Solidification imperfections: segregations, shrinkage, gas cavities, cracks - Origins of the laminar morphology Mechanical properties - Tensile, yield stresses, $RP_{0,2}$, Elongation, impact toughness, hardness - Elastic/plastic deformation - Fragile and ductile rupture : Influence of the structure, the temperature, mechanical and geometrical factors - Cold and hot deformation - Strengthening mechanisms (cold working, solid solution, precipitation hardening, grain size control, solid state transformation) - Recrystallisation			X
Learning outcomes for IWI-B: 1. Outline the main crystalline structures and their influence in the mechanical propierties. 2. Recognise how elastic-plastic deformation works, their role in cold and hot deformation and their influence in the mechanical propierties. 3. Idenify the effects of recristallisation on mechanical propierties. 4. Outline the relationship between mechanical properties and temperature, grain size and structure.			

2.2 Iron-Carbon alloys			
Objectives for IWI-B: Understand the principles of alloying iron with carbon, the crystalline structures developed under equilibrium and non-equilibrium conditions and their representation in phase and transformation diagrams.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**2**
Basic knowledge on the following items: Fe-C equilibrium diagram (steels) Equilibrium and non equilibrium transformations Equilibrium and non equilibrium components Concept of CCT diagrams (Continous Cooling Transformation) Properties of Carbon steel structures (equilibrium and non equilibrium) Influence of alloying elements Carbide forming elements			X
Learning outcomes for IWI-B: 1. Name the main structures in iron-carbon alloys (steels) under equilibrium and non-equilibrium conditions and their influence in mechanical propierties. 2. Understand the influence of C and alloying elements on the mechanical propierties.			

2.3 Manufacture and classification of steels			
Objectives for IWI-B: Understand the principles of iron metallurgy, steel making and designation of steels			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**1**
Introduction to metallurgy and to the steel making processes Diferents steel products: plates, bars, profiles, castings, forgings,… Defects and inpurities in steels Overview of designation of steels (National, EN standards, Wr.No.)			X X X X
Learning outcomes for IWI-B 1. Identify the various steel making processes. 2. List the main material imperfections and their origins. 3. Identify types of steel product based on its classification..			

2.4 Structure of the welded joint

Objectives for IWI-B: Understand how the different metallurgical structures appear within a weldment,and the influence of the welding procedure on the properties of the joint.
Objectives for IWI-S:
Understanding details of parameters affecting the metallurgical structure of the welded joints.

Module	WT-C	WT-S	WT-B
Scope **Teaching hours**	**0**	**3**	**1**
Thermal effect of welding			
- Particularities of localized heating sources used in welding			X
- Definition of thermal cycle, thermal distribution, cooling rate (Tr800/500)			X
- Main factors in thermal cycle and temperature distribution			X
- Effetcs of initial temperature, welding speed, heating power, process efficiency		X	
- Effects of the thickness, thermal conductivity, type of assembly and preparation of joint		X	
- Detailed definition and purpose of the heat input in welding (i.e. according to EN 1011-2)		X	
The heat-affected zone			
- Definition			X
- Consequences of heating			X
- Transformation during cooling			X
- Principle and use of CCT, CCTW curves and thermal graphs		X	
The weld metal			
- Definition of of weld metal and dilution			X
- Factors affecting the weld pool chemical composition: dilution, environment, volatilization		X	
- Solidification structure			X
- Ageing due to nitrogen		X	
- Influence of Solidification on soundness of the weld		X	
Single-pass and multi-pass welds.		X	X

Learning outcomes for IWI-S
1. Describe the influence of heat input, workpiece and joint configuration, welding process and deposited metal on the material properties.
2. Describe the influence of multi-pass welding compared to single-pass welding on the material properties.
3. Describe the influence of cooling speed on the material properties based on CCTW curves

Learning outcomes for IWI-B
1. Give the definition of thermal cycle, temperature distribution, heat input and cooling rate.
2. Outline the structure of the welded joint.
3. Identify differences between single-pass and multi-pass welding.

2.5 Cracking phenomena and imperfections in welding of steels			
Objectives for IWI-B: Understand the fundamentals of cracking mechanisms in welding of steels and the way they are influenced by welding variables. Gain basic knowledge on weld imperfections.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**3**
For C-Mn, low alloy, high alloy and stainless steels as appropriate:			
Cold cracking: - Description and localisation in weld metal and HAZ - Cracking mechanism and factors: hydrogen, brittle microstructure, stresses - Influencing factors: parent metal, design and welding sequence, low hydrogen welding processes and consumables, high heat input, preheating, interpass temperatures, post-heating, immediate PWHT, austenitic consumables (linked to low heat input)			X
Hot cracking: - Description and localisation in weld metal (solidification cracking) and HAZ (liquation cracking) - Cracking mechanisms and factors: sensitive structure, large solidification interval, stress - Influencing factors: parent metal and consummables, heat imput and welding speed, interpass temperature, design and welding sequence, selection of consumables, dilution			X
Lamellar tearing: - Description and localisation in parent metal and HAZ - Cracking mechanisms and factors : sensitive materials, impurities, joint configuration, type and direction of loading - influencing factors: parent material, joint design, welding procedure and welding sequence			X
Overview on welding imperfections: - Other cracking phenomena (e.g. reheat cracking) - Other imperfections (e.g. cavity, lack of fusion, inclusions, weld run morphology/shape)			X
Learning outcomes for IWI-B 1. Name and list the main types of cracking encountered in welding. 2. List the main factors affecting each type of cracking. 3. List the most common welding imperfections.			

2.6 Fractures and different kinds of fractures (including relation with defects)			
Objectives for IWI-B: Understand the relationship between the fracture surface aspect and the type of fractures.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**1**
Definition of: - Brittle fractures, ductile fractures - Fatigue fractures - Creep fractures - Practical examples (specimens or pictures)			X
Learning outcomes for IWI-B: 1. Identify different types of fractures. 2. Differentiate between fracture types for a given fracture surface aspect.			

2.7. Heat treatments of base materials and welded joints			
Objectives for IWI-B: *Understand the metallurgical transformations of materials during different heat treatment.*			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**2**
Definition of the main heat treatments: Normalising, Hardening, Quenching and tempering, Solution annealing, Homogenisation, Stress relieving (PWHT), Recrystallisation annealing, Precipitation hardening			X
PWHT in practice: - Heat treatment equipment (e.g., localized, global, in shop/on site). - Regulations (codes, specifications and technical reports). - Temperature measurement and recording.			X
***Learning outcomes for* IWI-B** 1. List the major heat treatments. 2. Identify the requirements to perform PWHT.			

2.8 Carbon, low alloyed, fine grained and thermomechanically treated steels (ISO/TR 15608 groups 1, 2, 3)			
Objectives for IWI-B: Understand the metallurgical effects in C, C-Mn, micro-alloying and alloying elements and thermomechanical trated steels. Mechanical properties and weldability.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**4**
General principles of the weldability of metallic materials (ISO/TR 581, EN 1011-1, ISO/TR 17671-1)			X
Definition of the weldability (metallurgical, constructional, operative, other…)			X
For the following steel families:			X
- Carbon and low-alloy steels			X
- Fine grained steels			X
- Thermomechanically treated steels			X
Explain:			X
- Chemical composition			X
- Structure and specific hardening treatments			X
- Mechanical properties			X
- Main grades and classification and grouping			X
- Weldability problems			X
- Structure on the weld metal and the HAZ in single-pass and multi-pass welding			X
- Influence of welding on the mechanical properties			X
- Welding procedures: welding process and consumables, heat input, initial temperature, inter-pass temperature, PWHT			X
- Typical provisions in welding codes/standards (e.g. EN 1011-2, ISO/TR 17671-2)			X
Learning outcomes for IWI-B 1. Identify a steel by its classification and briefly describe its structure and properties. 2. Outline the weldability problems of a steel according to its grade or designation. 3. Identify welding variables affecting weldability.			

2.9 Introduction to weldability of low alloyed and high alloyed steels			
Objectives for IWI-B: *List the main types of steels. Gain basic knowledge on their weldability.*			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**2**
Overview of the main types of steels used in welding and of the weldability			X
- Heat-treatment steels			X
- Structural steels			X
- Steels for pressure vessels			X
- Low alloy steels for low temperature applications			X
- Creep-resistant low alloy steels			X
- High yield strength steels			X
- Stainless steels (weldability limited to austenitic stainless steels)			X
Brief description of their typical chemical composition, structure and delivery state, groupings of matariels			
Learning outcomes for IWI-B			
1. List the main types of steels and outline their main metallurgical characteristics.			
2. Outline the principle of groupings of materials according to their weldability.			

2.10 Low alloyed creep resistant steels (ISO/TR 15608 groups 4, 5, 6)			
Objectives for IWI-S: Understand welding aspects of creep resistant steels and the relevant applications .			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**2**	**0**
Owerview of the metallurgy and weldability of the creep resistant steels, including:		x	
• Creep mechanisms			
- Creep stages and damage description			
- Creep resistance			
• Creep resistant steels			
- Chemical composition			
- Structure and specific hardening treatments			
- Temper embrittlement, 475° -brittleness,			
- Mechanical properties			
- Main grades designation and grouping			
• Weldability of creep resistant steels			
- Cracking phenomena			
- Structure on the weld metal and the HAZ in single-pass and multi-pass welding			
- Influence of welding on the mechanical properties			
- Welding procedure: welding process and consumables, heat input, initial temperature, inter-pass temperature			
- Post weld heat treatment and reheating cracking			
- Quality control of the welded joint			
- Recommendations for welding in codes and standards(e.g. EN 1011-2, ISO/TR 17671-2)			
Learning outcomes for IWI-S			
1. List the typical creep resistant and heat resistant grades of steels.			
2. Check the suitability of a welding procedure according to the requirements provided in codes or standards.			

2.11 Low alloy steels for cryogenic applications (ISO/TR 15608 group 9)			
Objectives for IWI-S: Understand welding aspects of low alloy steels for cryogenic applications and the relevant applications.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**1**	**0**
Owerview of the metallurgy and weldability of low alloy steels for cryogenic applications, including: • Main fields of applications • Requirements for low temperature applications • Low alloy cryogenic steels - Chemical compotion - Structure : effects of alloy elements (nickel), grain size - Mechanical properties - Main grades designation and grouping • Weldability of low alloy cryogenic steels - Structure on the weld metal and the HAZ in single-pass and multi-pass welding - Influence of welding on the mechanical properties - welding procedure: welding process and consumables, heat input, initial temperature, inter-pass temperature - Quality control of the welded joint • Recommendations for welding in codes and standards(e.g. EN 1011-2, ISO/TR 17671-2)		X	
Learning outcomes for IWI-S 1. List the typical low alloy cryogenic steels. 2. Chek the suitability of a welding procedure according to the requirements provided in codes or standards.			

2.12 Introduction to Corrosion			
Objectives for IWI-S*:* Outline the fundamentals of the various types of corrosion.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**1**	**0**
Overview of corrosion phenomena: • Fundamentals of corrosion : electrochemistry, redox potential, imunity, passivation, corrosion speed • Types of corrosion: overall corrosion, localized corrosion (pitting, crevice, stress corrosion crackin, galvanic, differential aeration) • Methods to prevent corrosion: - selection of the materials (corrosion tables) - storage, handling, tools, jigs,… used during manufacturing - welding procedure (including preparation) - pickling and passivation - cathodic protection - protective layer		X	
Learning outcomes for IWI-S: 1. Outline the chemical and electrochemical phenomena involved in corrosion. 2. List the most common types of corrosion. 3. Give examples of common protection methods.			

2.13 Stainless and heat resistance steels (ISO/TR 15608 groups 7, 8, 10)			
Objectives for IWI-S: Understand welding aspects of the various types of stainless steels and heat resistance steels and the relevant applications.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**4**	**0**
Fundamentals of stainless steels - Effect of alloying elements - Systems Fe-Cr, Fe-Ni, Fe-Cr-Ni - Austenite and ferrite formers: Cr- and Ni-equivalent - Influence of nitrogen		X	
Overview of weldability of the several types of stainless steels - Austenitics stainless steels - Ferritics stainless steels - Martensitics stainless steels - Duplex stainless steels		X	
Explaining: - Use of Schaeffler, DeLong and WRC diagrams - Suitability of filler materials: identification and control in workshop - $t_{12/8}$ weldability concept - Measuring of ferrite content (ISO 8249, ISO 17655) - Facilities for welding stainless steels: Tools, jigs - 475 °C-embrittlement - Weld decay (intergranular corrosion) - Pitting index: PRE, PREN - Applicable welding processes - Shielding and backing gases - Heat treatment - Post-weld heat treatment (PWHT) - Pickling and Passivation - Designation and classification (ISO, CEN and National)		X	
Recommendations for welding in codes and standards (e.g. EN 1011-3, ISO/TR 17671-3)		X	
Learning outcomes for IWI-S 1. List the typical stainless and heat resistance steels. 2. Chek the suitability of a welding procedure according to the requirements provided in codes or standards. 3. Check the suitability of treatment after welding according to the requirements provided in codes or standards.			

2.14 High Mn Carbon steels (ISO/TR 15608 group 11)			
Objectives for IWI-S: Overview the requirements for high alloy C-Mn steels and their weldability.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**1**	**0**	**0**
Overview of the metallurgy and weldability of the high manganese carbon steels, including: • Main fields of applications - Mining, wear and knotch resistance - Railways • High Mn Carbon steels - Chemical composition - Structure : effects of alloy elements (manganese), precipitation hardening - Mechanical properties - Main grades designation and grouping • Weldability of high Mn Carbon steels - Weldability problems - Structure on the weld metal and the HAZ - Influence of welding on the mechanical properties - Determination of the welding procedure : selection of the welding process and consumables, heat input, initial temperature, inter-pass temperature - Quality control of the welded joint • Recommendations for welding in codes and standards	X		
Learning outcomes for IWI-S 1. List the typical high Mn Carbon steels. 2. Check the suitability of a welding procedure according to the requirements provided in codes or standards.			

2.15 Cast irons (ISO/TR 15608 group 71 to 76) and cast steels			
Objectives for IWI-C: Interpret the metallurgy and /outline the different types of cast irons and cast steels, their application fields and weldability.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**2**	**0**	**0**
Overview of the metallurgy and weldability of cast iron and cast steels, including: • metallurgy and manufacturing of cast steels (including typical imperfections) • metallurgy and manufacturing of cast irons • Applicable welding processes and procedures (weldability, filler materials, etc.) • Application and special welding problems • Recommendations for welding in codes and standards (e.g. EN 1011-8, ISO/TR 17671-8)	X		
Learning outcomes for IWI-C 1. List the typical Cast Irons. 2. List the typical differences among cast steels and other steel products affecting weldability. 3. Check the suitability of a welding procedure according to the requirements provided in codes or standards.			

2.16 Nickel and Nickel alloys (ISO/TR 15608 Group 41 to 48)			
Objectives for IWI-C: Understand welding aspects of nickel/nickel alloys and the relevant applications.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**2**	**0**	**0**
Overview of the metallurgy and weldability of nickel and nickel alloys, including: • Pure metal physical and mechanical properties • Structural hardening : alloy elements, heat treatment • Alloys : designation, properties and typical applications • Weldability and typical welding deffects - Cracking phenomenon (hot cracking) - Pores - Embrittlement - Loss of strength in HAZ and weld metal - Operating weldability • Typical welding procedures - Applicable welding processes and heat input - Joint preparation - Shielding and backing - Selection of the filler material • Recommendations for welding in codes and standards	X		
Learning outcomes for IWI-C 1. List the typical nickel and nickel alloys. 2. Chek the suitability of a welding procedure according to the requirements provided in codes or standards.			

2.17 Aluminium and aluminium alloys (ISO/TR 15608 Group 21 to 26)			
Objectives for IWI-S: Understand welding aspects of Aluminium and Aluminium alloys and the relevant applications.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**2**	**0**
Overview of the metallurgy and weldability of nickel and nickel alloys, including: • Pure metal physical and mechanical properties • Structural hardening : alloy elements, cold working, heat treatment • Alloys : designation, properties and typical applications • Weldability, typical welding defects and their avoidance - Cracking phenomenon (hot cracking) - Pores - Distorsions - Loss of strength in HAZ and weld metal - Operating weldability • Typical welding procedures - Applicable welding processes and heat input - Joint preparation - Shielding and backing - Selection of the filler material • Recommendations for welding of aluminium and aluminium alloys (e.g. EN 1011-4, ISO/TR 17671-4)		X	
Learning outcomes for IWI-S 1. List the typical aluminium and aluminium alloys. 2. Chek the suitability of a welding procedure according to the requirements provided in codes or standards.			

2.18 Non ferrous materials (other than nickel and aluminium)			
Objectives for IWI-C: Overview the main properties and weldability aspects of the given alloys.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**2**	**0**	**0**
Overview of weldability of the several types of non ferrous metals: - Copper (ISO/TR 15608 Groups 31 to 38) - Magnesium - Titanium (ISO/TR 15608 Groups 51 to 54) - Zirconium(ISO/TR 15608 Groups 61 to 62) - Tantalum	X		
Explaining - Pure metal physical and mechanical properties - Designation and typical applications - Weldability and typical welding defects - Welding processes and filler materials - Typical welding procedure	X		
Learning outcomes for IWI-C 1. List the main weldability problems for each material. 2. List the main suitable welding processes for each material. 3. Give the main precaution to be implemented in the welding procedures for each material.			

2.19 Joining dissimilar materials

Objectives for IWI-C, IWI-S Understand the principles of joining dissimilar materials and the problems involved.

Module / Scope / Teaching hours	WT-C	WT-S	WT-B
	2	**2**	**0**
Fundamentals		X	
- Usual dissimilar materials welding configurations			
- Metallurgical compatibility (formation of intermetallic compounds, carbon migration)			
Weldability (for Standard level, limited to joining of different steels, including stainless steels)	X	X	
- Methology for analyzing a case of a heterogeneous joint			
- Control of the dilution: selection of the welding process and joint preparation			
- Use of the diagrams (e.g. Shaeffler, WRC, etc) for analyzing the case and determining the suitable filler material			
- Specific welding procedure and buttering			
Heat treatments		X	
Typical applications:			
- Joining low alloyed steel with mild steel		X	
- Joining high alloyed and stainless steel with mild steel		X	
- Joining CuNi alloys with mild steel/stainless steel	X	--	
- Joining Cu alloys with mild steel/stainless steel	X	--	
- Joining Ni alloys with mild steel	X	--	
- Joining Al alloys with mild steel	X	--	
- Joining Cu alloys with Al alloys	X	--	
- Joining Ni alloys with Cu alloys	X	--	

Learning outcomes for IWI-C

1. As relates to joining of steels to non-ferrous materials, check the suitability of a welding procedure according to the requirements provided in codes or standards.

Learning outcomes for IWI-S:

1. As relates to joining of of different steels, including stainless steels), check the suitability of a welding procedure according to the requirements provided in codes or standards.

2.20 Introduction to wear			
Objectives for* IWI-S*: Identify the fundamentals of wear.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**1**	**0**
Overview of different mechanism of wear: - hydrodynamic friction, - reaction, - layer wear, - adhesive wear, - abrasive wear, - fatigue wear, - fretting, - erosion, - cavitation, impact, thermal, dynamic)		X	
Overview of wear resistance materials: - hard materials - ductile materials		X	
Learning outcomes for IWI-S 1. Outline the mechanisms involved in wear. 2. List the most common types of wear.			

2.21 Protective layers

Objectives for* IWI-C*: Identify the fundamental processes and procedures, materials used for protective layers (involving non-ferrous materials).

Objectives for* IWI-S*: Identify the fundamental processes and procedures, materials used for protective layers (excluding non-ferrous materials).

Module	WT-C	WT-S	WT-B
Scope **Teaching hours**	**2**	**4**	**0**
Cladding (for Standard level, limited to steels cladded with corrosion and wear resistant steel overlays)*:* - Reasons for cladding and applications - Processes for cladding (dilution) - Joint design and welding procedures in respect of the accessibility to the joint . - Codes and Standards (e.g. EN 1011-5, ISO/TR 17671-5)	X	X	
Linings: - Welding of linings - Joint design and welding procedures		X	
Surfacing (for Standard level, limited to steels overlays and build-up made of steels)*:* - Corrosion-resistant layers - Wear-resistant layers	X	X	
Coatings: - Surface-coated steels - Galvanised steels (Si-content) - Painting - Problems of joining		X	

Learning outcomes for IWI-C

1. Check the suitability of a welding procedure for welding clad steels, welding coated steels, lining, surfacing, in the case of steels cladded or overlayed by non-ferrous materials.

Learning outcomes for IWI-S

1. Describe the main techniques for applying protective layers and the reasons for their choice.
2. Outline the problems associated to each technique.
3. Check the suitability of a welding procedure for welding clad steels, welding coated steels, lining, surfacing, in the case of steels cladded or overlayed by ferrous materials.

	WT-C	WT-S	WT-B
Module 3 Construction and design	**2**	**3**	**5**

3.1 Basic theory of structural systems and fundamentals of the strength of materials			
Objectives for IWI-B: Outline the basic mechanical properties for a gicven material and their relationship with the types of loading.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope / **Teaching hours**	**0**	**0**	**1**
Relationship between external loads and internal forces			X
Types of stresses (normal stress, shear stress)			X
Static, dynamic and thermal loading			X
Types of deformation (axial strain, shear strain)			X
Stress-strain relationship			X
Elastic and plastic deformation			X
Characteristic material properties			X
Learning outcomes for IWI-B			
1. Identify the differences between elastic and plastic deformation.			
2. List the types of loading.			
3. Identify for a given material the more significant mechanical properties.			

3.2 Welded Joint Design			
Objective for IWI-B: Understand types of joints and welds and the relationship with applications			
Module	**WT-C**	**WT-S**	**WT-B**
Scope / **Teaching hours**	**0**	**0**	**1**
Type of joints (T, butt, lap, etc) and of welds (full and partial penetration, fillet)			X
Influence of type of loading in the choice of the type of joint / weld			X
Joint classes/categories according to codes and standards			X
Types of welded joints (ISO 9692 series, EN 14324 brazing) and the relevant use in:			X
- Pressure vessels			
- Piping			
- Structures			
- Reinforcing bars			
- Etc.			
Learning outcome for IWI-B			
1. Recognise different types of welded joints.			

3.3 Fabrication drawings			
Objectives for IWI-B: Being able to identify weldments using drawings.			
Module / **Scope** / **Teaching hours**	**WT-C** **0**	**WT-S** **0**	**WT-B** **3**
Types of drawings (2D, 3D, sections, sketches, assemblies)			X
Representation of welded components in fabrication drawings			X
Tolerance requirements (ISO 13920, ISO 9013)			X
Welding symbols on drawings, symbols for groove shapes			X
Symbolic representation of welded, brazed and soldered joints according to ISO 2553			X
Practical examples			X
Learning outcomes for IWI-B			
1. Read welding symbols on drawings.			
2. Identify the welded components on the shop floor against fabrication drawings.			
3. Identify applicable tolerances as reported on drawings.			

3.4 Behaviour of welded structures under different types of loading			
Objectives for *IWI-S:* Outline the relationship among welded joint design and the behaviour of the structures under different types of loading.			
Module / **Scope** / **Teaching hours**	**WT-C** **0**	**WT-S** **2**	**WT-B** **0**
Static strength		X	
Elevated temperature strength		X	
Low-temperature strength		X	
Fatigue strength (S-N curves)		X	
Creep resistance		X	
Impact behaviour		X	
Influence of notches and weld defects		X	
Applicability of Joint improvement techniques (needle peening, TIG dressing, burr grinding, hammering, stress relieving, etc.)		X	
Learning outcomes for IWI-S			
1. Understand the relationship between design requirements and the behaviour of wedled components under different types of loading.			
2. List the joint improvement techniques.			

3.5 Design of aluminium alloys structures			
Objectives for IWI-S: Outline the relationship among welded joint design and the behaviour of aluminium welded components.			
Module / **Scope** / **Teaching hours**	**WT-C** **0**	**WT-S** **1**	**WT-B** **0**
Comparison of design between steel and aluminium structures		X	
Effects of heat-affected zone softening on design		X	
Special design regarding profiles		X	
Significance of defects and other specific requirements for fabrication		X	
Learning outcomes for IWI-S			
1. Identify relationship between design and softening of the heat-affected zone.			
2. Give examples of common aluminium weld joint details.			
3. List specific requirements for fabrication of aluminium welded components.			

3.6 Introduction to fracture mechanics			
Objectives for IWI-C: Overview the use of fracture mechanics for welded structures.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**2**	**0**	**0**
Overview of the following items: • Viewpoint of fracture mechanics • Application of fracture mechanics to Fitness for service and Fitness for Purpose (including use in standards and codes) • Relationship between fracture mechanics and acceptance criteria (factors which influence the behaviour of welded joints) • Fundamentals of Linear elastic and elastic-plastic fracture mechanics (critical flaw size, KIc-value) • Basic principles of fracture mechanics testing	X		
Learning outcomes for IWI-C 1. Identify the principles of fracture mechanics. 2. Identify the factors which influence the behaviour of welded joints in relationship with fracture mechanics.			

	WT-C	WT-S	WT-B
Module 4. Fabrication, applications engineering	**0**	**2**	**6**

4.1 Welding stresses and distortion			
Objectives for IWI-B: Get a general knowledge on the main factors affecting welding stress and distortion in welded fabrications and how these effects can be minimised.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope / **Teaching hours**	**0**	**0**	**2**
Origin of the residual stresses and distortion			X
Longitudinal and transverse shrinkage stresses			X
Types of distortions induced by welding (longitudinal, transversal and angular)			X
Overview of influencing factors: - thermal expansion of different materials - heat input - wedling sequences and techniques - joint details (shape, bevel, volume, single/double side, placement in respect of the component geometry, etc.)			X
Effects of residual stresses on the behaviour of the structure in service			X
Principles of methods of reducing residual stresses or distortion			X
Correction and removal of welding stresses and distortions (mechanical and thermal) and applicability to materials			X
Learning outcomes for IWI-B 1. Outline in general terms the origin, influencing factors and magnitude of residual stress and distortions in welded fabrications. 2. Identify procedures to minimise distortions and stresses. 3. Outline how residual stresses may affect the behaviour of a structure in service.			

4.2 Plant facilities. Welding jigs and fixtures			
Objectives for IWI-B: Acquire knowledge about the main plant facilities used during welded construction and auxiliary equipment			
Module	**WT-C**	**WT-S**	**WT-B**
Scope / **Teaching hours**	**0**	**0**	**2**
Layout of production line			X
Jigs, fixtures and positioners (types, applications, advantages, special precautions)			X
Roller beds, manipulators			X
Cables, electrical connections, and special precaution			X
Joint fit up			X
Tack welding and their removal			
Equipment for preheat, postheat, and other heat treatments, as well as temperature control including furnace and local heat treatment			X
Importance of maintenance			X
Learning outcomes for IWI-B: 1. Recognise the advantages of using fixtures, jigs and positioners. 2. Recognise the type of fixture, jig and positioner to be used in a certain welded construction. 3. Recognise the necessary characteristics for the auxiliary equipment to be used in a certain welded construction and the relevant maintenance (cables, heat treatment and temperature control). 4. Outline the general precautions related to joint fit up and tack welding.			

4.3 Health and safety			
Objectives for IWI-B: Understand the welding related health and safety risks and how to apply relevant requirements/measures.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**0**	**2**
Introduction to health and safety requirements			X
Survey of health and safety aspects related to welding and allied processes in the working environment, including as a minimum:			X
- Hazards of electric power			X
- Electro-magnetic fields			
- Connecting of equipment			
- Problems with shielding gases			
- Radiation and eye protection			
- Welding fume emission			
- Ventilation and fume extraction			
- Ergonomics			
- Noise levels and ear protection			
- Mechanical risks			
- Heat and hot materials			
Preventive and protective measures			X
Special risks for automated processes			X
Overview of requirements in standards and regulations			X
Learning outcomes for IWI-B:			
1. List the risks associated with welding from electricity, gases, fumes, fire, radiation, heat and noise.			
2. Comply with health and safety regulations with respect to the above hazards.			
3. Understand the use of applicable Personal Protective Equipment.			

4.4Repair-welding			
Objectives for IWI-S: Understand repair welding procedures and specifications both for in-manufacture and in-service situations.			
Module	**WT-C**	**WT-S**	**WT-B**
Scope **Teaching hours**	**0**	**2**	**0**
Special factors affecting welding repairs on new and serviced compnents, including the working environment.		X	
Specific techniques used in repair welding, including (as a minimum):		X	
- Techniques for removing material		X	
- Buttering			
- Hammering and shot peening			
- Wedling stiffeners			
- Welding operational techniques and welding sequences			
- Starts and stops			
- Weld joint details			
- Post weld heat treatments			
Welding repair procedure specification		X	
Welding repair plan, including requirements for quality control		X	
Overview of Standards/Codes and regulations		X	
Learning outcomes for IWI-S:			
1. Explain the problems and implications of making repair welds.			
2. Checking and verifying procedures to be applied to weld repairs.			

	WT-C	WT-S	WT-B
TOTAL:	**26**	**30**	**47**

Theoretical Education: Welding Inspection Modules

Module 1. Quality Assurance / Quality Control in Inspection	WI-C	WI-S	WI-B
Number of Course Hours:	10	14	18

1.1 Scope of activity, terms and definitions

Objectives for IWI-B: To gain an understanding of the objectives of welding inspection, the goal of construction codes and quality standards, the inspection stages and the inspector's relationship with other welding personnel. To gain knowledge regarding the purpose of destructive and non destructive testing and inspection and NDT terminology.

Scope	Module: Teaching hours	WI-C: 0	WI-S: 0	WI-B: 1
Objectives of inspection in welded construction				X
Basic information about construction and quality standards				X
Inspection before, during and after welding				X
Concepts of destructive and non-destructive testing				X
Introduction to the concept of fitness for purpose				X
Common Inspection and NDT terms				X
Reference standards for terminology (ISO 25901, ISO 18173)				X

Learning Outcomes for IWI-B

1. Point out the objective of welding inspectors in construction codes and quality standards.
2. Identify the advantages and disadvantages of destructive and non destructive testing.
3. Explain the welding inspector's job function in welding construction.

1.2 Role of Welding Inspection Personnel

Objectives for IWI-B: To understand the role and responsibilities and job funtions of the welding inspector and the inspector's atitude and ethics.

Scope	Module: Teaching hours	WI-C: 0	WI-S: 0	WI-B: 1
Role of inspection personnel in the assurance of product quality				
Welding inspector levels and their qualification (IIW IAB-041)				X
NDT personnel and their levels of qualification/certification (ISO 9712)				X
Relationships with welding coordinator, NDT personnel and other personnel with welding tasks				X
Responsibilities of inspector; liability for actions				X
Welding inspectors attitude and code of ethics (including impartiality, confidentiality and independence)				X

Learning Outcomes for IWI-B

1. Explain the role and responsibilities of welding inspectors in construction codes and quality standards.
2. Identify the levels of personnel qualification and the associated job tasks and responsibilities in inspection and testing.
3. Identify the relatioships with other welding personnel and the associated job tasks and responsibilities in welding co-ordination.
4. Identify the role of the welding inspector and the relationship with the NDT personnel.
5. Identify the main aspects regarding the inspector attitude and code of ethics.

1.3 Management of inspection function

Objectives for IWI-C: To understand the responsibilities associated with inspection activities as they relate to staff, company/organisation and record generation and retention. To recognise the importance of accurate records and monitoring of activities with respect to the inspection process.

Objectives for IWI-S: To recognise the importance of accurate records and monitoring of activities with respect to the inspection process

Module / **Scope**	**WI-C** / **Teaching hours**	**WI-S**	**WI-B**
	2	**1**	**0**
Responsibilities; organisation; personnel; personnel management; discip motivation of subordinates; staff development; planning and scheduling of activities; records and record keeping.		X	
Introduction to ISO/IEC 17020		X	
Use of ISO/ 17020	X		

Learning Outcome for IWI-C

1. Be able to define a plan to implement ISO/IEC 17020

Learning Outcome for IWI-S

1. Outline the implementation principles of ISO/IEC 17020.
2. Be familiar with typical inspection company procedures relating to staffing and inspection task implementation.
3. Understand basic project planning techniques and how they are applied to inspection activities.

1.4 Quality Assurance Principles in Welding

Objectives for IWI-C: To gain a detailed understanding of the principles of quality assurance and quality control and recognise the related standards and their application to welded fabrication as a special process.

Objectives for IWI-S: To gain a comprehensive knowledge of the principles of quality assurance and quality control and recognise the related standards and their application to welded fabrication as a special process.

Objectives for IWI-B: To gain knowledge of the principles of quality assurance and quality control and recognise the related standards and their application to welded fabrication as a special process.

Module	WI-C	WI-S	WI-B
Scope **Teaching hours**	**2**	**2**	**2**
Concept of quality assurance and quality control (including analysis, continuous improvement	X	X	X
Quality manual		X	X
Quality plan (ISO 10005)		X	X
Auditing (Audit plan, opening and closing meeting, ISO 19011)	X		
Key factors to ensure QA/QC, personnel and equipment, maintenance, inspection			X
Standards (QMS guidebook, ISO 9001, ISO 3834, for IWI-B only basic information)	X	X	X
Level of QA required versus product specification (for IWI-B only basic information)	X	X	X
Risk and consequences of failure (for IWI-B only basic information)	X	X	X
Produc liiability	X	X	
Role of quality control and inspection in QA	X	X	
Implementation of standards in a fabrication environment	X	X	
Auditing of suppliers and sub-contractors, witness audits	X	X	

Learning Outcome for *IWI-C*

1. Explain the principles of quality assurance, quality control and inspection systems and their usage for welded fabrication.
2. Be capable of writing quality control procedures and quality plans for welded fabrication.
3. Describe the purpose of an audit plan.
4. Be capable of carrying out audits of welding related plant, personnel, equipment and product.
5. Describe the main factors related to personnel and equipment which influence the quality of a welded fabrication.

Learning Outcome for IWI-S

1. Describe the main differences between quality assurance, quality control and inspection systems and their usage for welded fabrication.
2. Be capable to apply, follow, supervise the quality control procedures implementation
3. Interpret appropriate standards (e.g. ISO 9001, and ISO 3834 series).
4. Know the basic factors related to personnel and equipment, which influence the quality of a welded fabrication.
5. Be capable of interpreting the inspector's role during fabrication activities

Learnig Outcome for IWI-B

1. General outline on the goals for quality assurance and quality control.
2. Recognise some factors related to personnel and equipment, which influence the quality of a welded construction.
3. Follow and apply quality assurance and quality control procedures

1.5 Welders/Welding Operators and Welding Procedures approval

Objectives for IWI-S: Gain a complete knowledge of the standards related to welders/operators and welding procedure qualification. The same objectives to be covered in the scope for Brazing and Reinforcing Bars.

Objectives for IWI-B: Gain the knowledge of the standards related to welders/operators and welding procedure specification. The same objectives to be covered in the scope for Reinforcing Bars.

Module	WI-C	WI-S	WI-B
Scope **Teaching hours**	**0**	**6**	**10**
Welder qualification (ISO 9606 series, and national standards)			X
Welding operator qualification (ISO 14732, and national standards)			X
Welding procedure specification (WPS) - how to create and develop (ISO 15609, and national standards)		X	X
Procedure qualification (as described in ISO 15607) and National standards		X	
Reinforcing Bars, welders/operators and procedures (ISO 17660, and National standards)		X*	X
Brazing, brazers/operators (ISO 13585, and national standards) and procedures (EN 13134, and National standards)		X	X
Stud welding operators and procedures (ISO 14555 and national standards)		X*	
Note: Paper exercise on checking, reviewing and evaluating welders approvals, WPS and WPQRs shall be included (at least 3 hours of 10 for WI-B, 2 hours of 6 for WI-S)			
X* - Only in what regards the WPS and WPQRs, concerning the welder/operator approval a short review.			

Learning Outcome for IWI-S

1. Explain the purpose of a welder/operator approval.
2. Understand the standards for welder/operator approval, be able to determine the main variables for a particular welder qualification and its range of qualification (including brazing, welding of reinforcing bars).
3. Explain the the process for developing a WPS
4. Explain the purpose of a WPS/WPQR/pWPS..
5. Recognise and determine the content of an WPQR in according to Intenrational Standards and/or National Standards
6. Recognise the main variables for a certain WPQR and its range of approval.
7. Be able to review and evaluate a WPSs and/or a WPQR for welded components in accordance with national and international standards.
8. Understand the standard for approval of a WPS and/or WPQR, determine the main variables for a particular WPS qualification and its range of qualification in accordance with National and/or International standards (either for welding, brazing or reinforcing bars).

Learnig Outocome for IWI-B

1. Outline the purpose of welder/operator approval and procedure qualification .
2. Be able to review and evaluate a welder/operator approval for acceptance with applicable standards and specification.
3. Outline the main variables for a specific welder/operator approval and its range of approval..
4. Ba able to review and evaluate a WPS for acceptance with applicable standards and specification.
5. Be able to witness and prepare a welder qualification test report.

1.6 Measurement, inspection and control during welding			
Objectives for IWI-B: To gain an outline of the requirements for measurement, testing and control during welding and allied operations.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope **Teaching hours**	**0**	**0**	**2**
Methods and instruments for the measurement			
- Of the the following variables:electrical parameters (voltage, current and power)			X X X
- Temperatures (ISO 13916), humidity, wind			X
- Cooling time e.g. t 8/5, and t 12/8,			X
- , welding velocity and wire velocity, gas flow rate			X
- Control in heat treatment (e.g. heating and cooling rate, CR ISO 17663, evaluation of conformity to specifications)			X
Calibration, verification and validation requirements of equipment (ISO 17662), including the NDT equipment			X
Checking the “calibration” documents			
Laboratory exercises.			
Learning Outcome for IWI-B: 1. Recognise methods of measurement used in the control of welding. 2. Recognise working procedures for the measurement of welding parameters. 3. Recognise the need for calibration of equipment, and the methods to validate calibration.			

1.7 Types of imperfections			
Objectives for IWI-B: Gain knowledge to be able to identify the characteristics of the fundamental types of weld imperfections. Recognsie their possible position with reference with the welded joint and to verify their visibility with the current NDT techniques.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope **Teaching hours**	**0**	**0**	**3**
Review of weld imperfections, their cause and characteristics, particular			X X
- Porosity and cavities			X
- Imperfect and profile shape			X
- Arc strikes			X
- Cracks			X
- Inclusions			X
- Lack of fusion			X
- Lack of penetration			X
- Lamellar tearing			X
- Overlap			X
- Poor surface condition			X
- Seams and laminations			X
- Spatter			X X
- Undercut			X
Other imperfections, e.g.: Base material imperfections such as laminat			
Classification (ISO 6520-1/-2, ISO 18279, ISO 17658), others			
Learnig Outcome for IWI-B 1. Identify the causes of weld imperfections, with reference to the different welding processes and welded materials. 2. Recognise the different types of weld imperfections.			

1.8 Evaluation of Imperfections			
Objectives for IWI-B: Gain knowledge with regards to defect significance and to be able to compare between families of imperfections and their significance. To Understand the morphology of the imperfections. To recognise the possible influence of each type of imperfection. To be able to apply International and National Standards and codes for acceptance/rejection criteria of weld imperfections.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope **Teaching hours**	**0**	**0**	**1**
Features of weld imperfections:			
volumetric form			X
nature of surface			X
size			X
location			X
orientation			X
Relation between product performance, related construction code/standards, and quality level of imperfections			X
Acceptance/rejection criteria (ISO 5817, ISO 10042, ISO 9013, ISO 13919-1/-2 and ISO 17635, and national standards)			X
Learning Outcome for IWI-B			
1. Gain knowledge of imperfection significance including comparison between imperfection families.			
2. Application of imperfections acceptance/rejection criteria standards.			

1.9 Engineering Critical Assessment			
Objectives for IWI-C: To gain an understanding of the need for and use of engineering critical assessment techniques.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope **Teaching hours**	**2**	**0**	**0**
Significance of defects (morphology and location of defects)	X		
Engineering critical assessment techniques	X		
Applicable reference documents, including codes/standards and IIW recommendations	X		
Learning outcomes for IWI-C			
1. Describe the principles of engineering critical assessment.			
2. Describe in detail the effect of imperfection size, morphology and position on structural integrity.			
3. Explain typical procedures to conduct an engineering critical assessment of a welded structure.			

Module 2 Testing of welds and Reporting	WI-C	WI-S	WI-B
Number of Course Hours:	10	14	18

2.1 Destructive testing of welded joints

Objectives for IWI-S and IWI-B: To understand the purpose and value of destructive testing in relation to welding procedure and welder qualification tests. To understand the requirements for material used for procedure and performance testing.

Scope / Module / Teaching hours	WI-C	WI-S	WI-B
	0	2	3
Purpose of welding procedure tests		X	
Purpose for welder qualification tests			X
Purpose of the production tests			X
Witnessing performance tests and destructive testing of test pieces			X
Preparation of test pieces			X
Material requirements for test pieces including certificates		X	X
Tensile tests (ISO 4136)			
Bend tests (ISO 5173)			X
Fracture tests (ISO 9017)		X	X
Hardness tests (ISO 9015-1/-2)		X	
Impact Tests (ISO 9106)			
Other tests required by the codes/standards (e,g. drop weight, intergralular tests, cold and hot cracking, Ferrite number)		X	
Mechanical tests reports contents and verification of contents		X	X
Macro examination (ISO 17639)			X
Micro examination		X	X
Macro and micro reports contents and verification of contents		X	X
Applicable standards			X

Learning outcomes for IWI-S

1. Explain the purpose and value of destructive testing in relation to service performance.

Learning outcomes for IWI-B

1. Understandi the objectives of welding procedure and welder qualification tests.
2. Understand test reports, information and content.
3. Select the appropriate test that is requested by the code/standard.
4. Able to witness performance tests.

2.2 Overview of NDT methods

Objectives for IWI-B: To understand the general principals of different NDT methods and their advantages and disadvantages.

Scope / Module / Teaching hours	WI-C	WI-S	WI-B
	0	0	1
Introduction to test methods.			X
Range of application of different NDT methods (PT.MT, RT, UT) ISO 17635.			X
Advantages and disadvantages of surface and volumetric test methods.			X

Learning outcomes for IWI-B

1. An understanding of the range and application of the most common NDT test methods.

2.3 Visual Inspection			
Objectives for IWI-B: To understand the principals of visual inspection and acceptance criteria and be able to perform visual inspection and understand NDT test reports.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope **Teaching hours**	**0**	**0**	**2**
Overview			X
Visible defect types			X
Dimension checks			X
What to look for before, during and after welding			X
Inspection tools			X
Reporting			X
Standards (ISO 17637, ISO 5817)			X
Learning outcomes for IWI-B 1. Understand the purpose of visual inspection at all stages of welding. 2. Understand the purpose and limitations of tools used to aid visual inspection. 3. Able to perform visual inspection and report in detail the defects identified during an inspection.			

2.4 Liquid penetrant testing (PT)			
Objectives for IWI-B: To understand the fundamentals of liquid penetrant testing and be able to understand NDT test reports.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope **Teaching hours**	**0**	**0**	**2**
Principles and application of different equipment and test techniques			X
Limitations of the test techniques			X
Interpretation of indications			X
Standards (ISO 23277, ISO 3452-1)			X
The expected content of reports prepared by NDT personnel			X
Learning outcomes for IWI-B 1. Able to read and understand the implications of NDT reports.			

2.5 Magnetic particle testing (MT)			
Objectives for IWI-B: To understand the fundamentals of magnetic penetrant testing and be able to understand NDT test reports.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope **Teaching hours**	**0**	**0**	**2**
Principles and application of different equipment and test techniques			X
Limitations of the test techniques			X
Interpretation of indications			X
Standards (ISO 17638, ISO 23278)			X
The expected content of reports prepared by NDT personnel			X
Learning outcomes for IWI-B 1. Able to read and understand the implications of NDT reports.			

2.6 Radiographic testing (RT)

Objectives for IWI-S and IWI-B: To understand the fundamentals of radoiographic testing and be able to understand NDT test reports and film interpretation.

Module	WI-C	WI-S	WI-B
Scope **Teaching hours**	**0**	**2**	**2**
Principles and application of different equipment and test techniques			X
Basic safe working practices			X
Limitations of the test techniques			X
Quality of the RT film		X	
Film interpretation		X	
Standards (ISO 17636-1, ISO 10675-1)			X
The expected content of reports prepared by NDT personnel			X

Learning outcomes for IWI-S

1. Able to verify the film quality and perform basic interpretation of films.

Learning outcomes for IWI-B

1. Able to read and understand the implications of NDT reports.

2.7 Ultrasonic testing (UT)

Objectives for IWI-S and IWI-B: To understand the fundamentals of ultrasonic testing and be able to understand NDT test reports.

Module	WI-C	WI-S	WI-B
Scope **Teaching hours**	**0**	**2**	**2**
Basic knowledge regarding the pricinples and aplications of UT			X
Principles and application of different equipment and test techniques		X	
Limitations of the test techniques			X
Standards (ISO 17640, ISO 11666)		X	X
The expected content of reports prepared by NDT personnel			X

Learning outcomes for IWI-S

1. Able to be responsible for the acceptance of NDT test results from NDT personnel.

Learning outcomes for IWI-B

2. Able to read and understand the implications of NDT reports.

2.8 Advanced and other NDT methods

Objectives for IWI-C: To understand the fundamentals of advanced test techniques and other test methods including eddy current testing.

Module	WI-C	WI-S	WI-B
Scope **Teaching hours**	**4**	**0**	**0**
Principles and applications of advanced test techniques including Phased Array (ISO 13588), TOFD (ISO 10863, ISO 15626), and Digital radiography (ISO 17636-2, ISO 10675-2)	X		
Specialised test methods and equipment for pipe work and tanks	X		
Eddy current testing principles and applications (ISO 17643)	X		

Learning outcomes for IWI-C

1. Understand the availability and applicability of advanced and other test methods for welded constructions.
2. Explain the principles of advanced and other test methods.
3. Able to be responsible for the acceptance of the results of testing.

2.9 Critical review of selection of NDT methods			
Objectives for IWI-C, IWI-S: To understand the factors affecting the choice of NDT method for an inspection including the sensitivity of detection and cost implications.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope **Teaching hours**	**1**	**2**	**0**
Items to be considered for the selection of NDT methods (ISO 17635): - welding processes; - parent metal, welding consumable and treatment; - joint type and geometry (CEN/TR 15135); - component configuration (accessibility, surface condition, etc.); - quality levels; - discontinuity, location (internal and surface), type and orientation expected.		X	
Reliability of detection		X	
Defect identification		X	
Defect sizing		X	
Personnel factors	X		
Costs	X		
Learning outcomes for IWI-C 1. A thorough understanding of factors affecting the choice of NDT method. 2. Select NDT methods for complex welded constructions. **Learning outcomes for IWI-S** 1. Understand the factors affecting the choice of NDT method. 2. Select NDT methods for basic and standard welded constructions.			

2.10 Other test methods (pressure testing, dimensional tests, etc.)			
Objectives for IWI-C: To understand the principles of pressure, leakage and dimensional tests. **Objectives for IWI-S:** To witness and understand the principles of pressure testing and dimensional tests.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope **Teaching hours**	**1**	**2**	**0**
Review of the below principles and tests	X		
Health and safety standard requirements including test pressures		X	
Purpose of pressure testing		X	
Hydraulic and pneumatic tests	~~X~~	X	
Checking for leaks			
Significance of dimension checks and tolerances		X	
Measuring instruments and tools		X	
Learning outcomes for IWI-C 1. Understand the fundamentals of pressure, leakage tests and dimensional tests. 2. Able to accept the results of pressure tests and dimension tests. **Learning outcomes for IWI-S** 3. Able to witness pressure tests and to perform dimensional tests. 4. Able to accept the results of pressure tests and dimension tests.			

2.11 Qualification and certification of NDT personnel			
Objectives for IWI-B: To understand the system of training, qualification and certification of NDT personnel.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope **Teaching hours**	**0**	**0**	**1**
ISO 9712 system for qualification and certification of NDT personnel.			X
Expected capabilities of different levels of certification.			X
Learning outcomes for IWI-B 1. An understanding of the roles of the respective levels of personnel in preparing procedures, conducting tests, evaluating and reporting the results of tests.			

2.12 Documents for quality control in welding

Objectives for IWI-C: To understand the responsibilities associated with inspection activities as they relate to the management, quality control principles and the key documents used. Recognise the importance of accurate records with respect to the inspection process.

Objectives for IWI-S: Gain a complete knowledge with regards to management, review, evaluation, validation, quality control principles and the key documents used. Recognise the importance of accurate records with respect to the inspection process.

Objectives for IWI-B: Identify and be able to review, evaluate and validate the key documents that are used in the quality control.

Module / Scope / Teaching hours	WI-C	WI-S	WI-B
	2	2	3
Inspection and testing Plan: Goal (for IWI-B), content and sources of information (for IWI-C/S)	X	X	X
Weld Joints Traceability: Why and how to achieve it		X	
The use of drawings in welding inspection and how to read them			X
Material Tests Certificates: Goal of the MTCs, Types of MTCs (EN 10204, or national standards), content, how to review and validade MTCs	X	X	X
Destructive Testing Reports: Goal of DTRs, content, how to review and validate DTRs (tensile, macro, hardness, fracture, bending, others)			X
Non Destrutive Testing Reports: Goal of NDTRs, content, how to review and validate NDTRs (VT, LP, MT, RT, UT others)			X
Welder Approvals: Goal, content how to review and validate the documents			X
Welding Procedure Specifications: Goal, content, how to review and validate them			X
Welding Procedure Qualification Records: Goal, content, how to review and validate them			X
Note 1: At least 50% of the time shall be used for practical exercises. This will include exercises that cover the review and validation of documents and examples of reports and ITPs.			
Note 2: DTRs, NDTRS, Welder Aproval, WPSs and WPQRs are dealt within specific subjects so this information shall be a basic summary			

Learning Outcome for IWI-C

1. Explain how to develop an ITP.
2. Undestand the key factors necessary to implement an ITP.
3. Be able to develop a weld joint traceabilty scheme for a certain welded construction.
4. Have the knowledge and understanding to develop procedures for validation and review of welding inspection reports and records.

Learnig Outcome for IWI-S

1. Outline the typical structure of an ITP, how to implement, and to develop the necessary tasks.
2. Be able to develop a weld joint traceability scheme for a certain construction.
3. Identify the procedures necessary to review and validate the typical inspections records and reports.

Learnig Outcome for IWI-B

1. Be able to understand the content of an ITP.
2. Be able to develop the tasks related to an ITP.
3. Recognise the need of weld joints traceability.
4. Identify from drawings the parts to be inspected.
5. Review and validate the main inspections records and reports.

2.13 Economics in Welding Inspection			
Objectives for IWI-C: understand the influence of inspection costs on the welding fabrication overall cost, and the factors affecting welding inspection cost.			
Module	**WI-C**	**WI-S**	**WIT-B**
Scope **Teaching hours**	**2**	**0**	**0**
Introduction,	X		
Overview of welding manufacturing costs:	X		
Deposition rate, preheat/interpass, welding sequences, ergonomics).	X		
Costs of labour,	X		
Costs of consumables,	X		
Costs of equipment,	X		
Welder's duty cycle,	X		
Analysis of welding inspection costs,	X		
NDT equipments costs	X		
NDT methods consumables costs	X		
NDT Labour costs	X		
Learning outcomes for IWI-C:			
1. Describe the factors affecting welding inspectors costs.			

Module 3. Practical work on testing	WI-C	WI-S	WI-B
Number of Course Hours:	16	20	17

3.1 Radiographic interpretation

Objectives for IWI-C and IWI-S: To understand the basic principles of radiographic film interpretation and factors affecting test results.

Objectives for IWI-B: To understand the basic principles of radiographic film interpretation.

Scope / Module / Teaching hours	WI-C	WI-S	WI-B
	4	6	2
Viewing conditions			X
Overviewing of image quality			X
Verification of viewing conditions and image quality against the codes/standards/specifications/procedures	X	X	
Classification of imperfections (type, size, localization etc.)	X	X	
Evaluation against ISO 5817, using ISO 10675-1/-2	X	X	
Report of imperfections		X	
Checking the RT reports content			X

Learning outcomes for IWI-B:

1. Able to read radiographic interpretation test reports
2. An understanding of the implications of test reports

Learning outcomes for IWI-C and IWI-S:

1. An understanding of the factors affecting radiographic film interpretation.
2. An understanding of the defects detectable by radiography and the limitations of the test method.
3. Able to accept test reports and assess the implications of findings.

Note: The practical work described here is complementary to the theoretical classroom training for radiographic testing included in Welding Inspection module 2.6.

3.2 Witnessing mechanical tests

Objectives for IWI-S: To understand the basic principles of mechanical and metallographic tests.

Scope / Module / Teaching hours	WI-C	WI-S	WI-B
	0	2	0
Test piece preparation		X	
Tensile test		X	
Bend test		X	
Fracture test		X	
Hardness test		X	
Impact test		X	
Macro examination		X	
Micro examination		X	
Reporting		X	
Checking the Tests reports content		X	

Learning outcomes for IWI-S:

1. Understanding of the defects and mechanical properties detectable and measurable by mechanical tests and examinations.
2. Able to assess and accept reports from test laboratories.

Note: The practical work described here is complementary to the theoretical classroom training for destructive testing included in Welding Inspection module 2.1.

3.3 Visual inspection of Welds

Objectives for IWI-B: To understand the basic principles of visual inspection.

Module	WI-C	WI-S	WI-B
Scope **Teaching hours**	**0**	**0**	**6**
Viewing conditions			X
Measurement devices and gauges for visual inspection			X
Visual testing of joint preparation			X
Visual testing of the finished weld			X
Evaluation against ISO 5817			X
Reporting, verification of reports contents			X

Learning outcomes for IWI-B:

1. Able to conduct visual inspections.
2. Able to report the results of tests.

Note: The practical work described here is complementary to the theoretical classroom training for visual inspection included in Welding Inspection module 2.3.

3.4 Metallographic (Micro and Macros)

Objectives for IWI-C: To understand the basic principles of macro and micro metallographic examination.

Objectives for IWI-B: To understand the basic principles of macro metallographic examination.

Module	WI-C	WI-S	WI-B
Scope **Teaching hours**	**2**	**0**	**2**
Preparation of specimens for macro- examination for ferrous materials			X
Preparation of specimens for macro- and microscopic examination for ferrous and non ferrous materials	X		
Viewing conditions			X
Identification of defects and imperfections			X
Identification of basic metallographic microstructures	X		
Reporting and checking the reports content			X

Learning outcomes for IWI-B:

1. Able to read and understand laboratory test reports.

Learning outcomes for IWI-C:

1. An understanding of the purpose and scope of application of metallographic examination.
2. Able to explain the principles of metallographic examination.
3. Able to be responsible for the acceptance of the results of laboratory and site testing.

3.5 Liquid penetrant and magnetic particle testing

Objectives for IWI-B: To understand the basic principles of liquid penetrant and magnetic particle testing.

Module / Scope / Teaching hours	WI-C	WI-S	WI-B
	0	0	4
Viewing conditions			X
Surface conditions and preparation			X
Application techniques			X
Identification of indications			X
Reporting, checking the report contents			X

Learning outcomes for IWI-B:

1. An understanding of the factors affecting test results.
2. An understanding of the implications of test reports.

Note: The practical work described here is complementary to the theoretical classroom training for liquid penetrant and magnetic partical testing included Welding Inspection modules 2.4 and 2.5.

3.6 Ultrasonic testing (advanced techniques for IWI-C)

Objectives for IWI-C: To understand the principles of ultrasonic testing including advanced techniques.

Objectives for IWI-S: To understand the principles of ultrasonic testing.

Objectives for IWI-B: To understand the basic principles of ultrasonic testing.

Module / Scope / Teaching hours	WI-C	WI-S	WI-B
	2	2	1
Basic demonstrations			X
Surface conditions and preparation	X	X	
Range and sensitivity setting	X	X	
Thickness measurements	X	X	X
Scanning	X	X	
Advanced techniques	X		
Defect detection and characterisation	X	X	
Evaluation	X	X	
Reporting, checking the reports contents	X	X	X

Learning outcome for IWI-B:

1. Able to read and understand the implications of NDT test reports

Learning outcome for IWI-S:

1. Able to read and understand the implications of NDT test reports

Learning outcomes for IWI-C:

1. Understand the defects detectable with ultrasonic testing and its limitations
2. Able to assess test reports

Note: The practical work described here is complementary to the theoretical classroom training for ultrasonic testing included in Welding Inspection module 2.7.

3.7 Witnessing Welders approval (for IWI-B) and WPQRs (for IWI-S)			
Objectives for IWI-S: To understand the basic principles of welding procedure qualification tests. **Objectives for IWI-B:** To understand the basic principles of welder qualification tests.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope / **Teaching hours**	**0**	**2**	**2**
Specific applications of welding procedure qualification		X	
Witnessing of tack weld and welding of test pieces			X
Witnessing of testing of welded test pieces		X	X
Monitoring the WPS variables		X	
Drafting of WPQR		X	
Drafting of welder qualification test certificates			X
Learning outcomes for IWI-B: 1. Able to witness a welder qualification test. 2. Able to review and accept a welder qualification test certificate. ***Learning outcomes for IWI-S:*** 1. Able to witness a WPQR test. 2. Able to review and accept a WPQR test certificate.			

3.8 Application of testing in different fields and case studies (not only NDT)			
Objectives for IWI-C and IWI-S: To understand the basic principles of selecting NDT and/or other test methods for application in different fields.			
Module	**WI-C**	**WI-S**	**WI-B**
Scope / **Teaching hours**	**8**	**8**	**0**
Cases studies based on: Identifying the factors affecting the choice of NDT test method or combination test methods for a variety of applications Factors affecting the scope of testing Reviewing test reports and ITPs Acceptance of test reports Acceptance of NDT and DT procedures Review of Manufacturing/constructuion documents	X	X	
Learning outcomes for IWI-C 1. Able to select NDT methods for complex welded constructions. ***Learning outcomes for IWI-S:*** 1. Able to select NDT methods for basic and standard welded constructions. ***Note: The practical work described here is complementary to the theoretical classroom training for critical review of selection of NDT methods included in Welding Inspection module 2.9.***			

Welding Inspection Modules : Total hours 32 43 55

Section 2: Minimum requirements for qualification and examination of International Welding Inspection Personnel (IWIP)

1. Introduction

This Guideline seeks to achieve harmonisation and a common standard in the examination and qualification of personnel engaged in welding inspection. The national welding organisations, being members of the IIW, mutually acknowledge the Diploma awarded in any Member State to International Welding Inspection Personnel, following education, experience and examination conducted in accordance with this Guideline.

Before examination, education must have been followed that is prescribed in this Guideline, and the Authorised Nominated Body must have conducted the final examination.

2. Route from IWI-B to IWI-S and from IWI-S to IWI-C

In the case of standard Route 3, the candidate shall have had a minimum of 2 year's experience at the relevant level before entering the training (see Fig. 2).

3. Verification of visual acuity

All candidates shall provide evidence of a satisfactory vision test, carried out in accordance with requirements of EN ISO 9712.

4. Approval of courses

Any training course leading to the IIW 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 required to cover the syllabus are adequately represented in the team of teachers and visiting lecturers.

5. Examination Board

An Examination Board, acting on behalf of the ANB, supervises examinations. In this way, the independence, integrity and fairness of the examination system is maintained.

6. Admission to the Examination

Admission to the examination leading to the award of the International Welding Inspector level Comprehensive, Standard and Basic diploma will be restricted to those who comply with the minimum requirements specified in the Guideline, and

a) 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

- Who have attended a Distance Learning Course approved by the ANB fulfilling the requirements of Guideline IAB-195-see latest edition,

b) Alternative Route: Who have successfully passed the ANB detailed assessment (see Section 1, item 7)

7. Examination procedures

The examination will consist in a Welding Technology Exam, Welding Inspection Exam and Practical Exam as reported in table 1.

Requirements and rules for IWS 0 examination are reported in doc. IAB-252 in it's latest revison.

	Standard Routes		
	Route 1	**Route 2**	**Route 3**
Candidates to IWI-B	WTE-B WIE-B PE-B	WIE-B PE-B	
Candidates to IWI-S	WTE-S+WTE-B WIE-S+WIE-B PE-S	WIE-S+WIE-B PE-S	IWS 0 Examination (only for candidates not satisfying access conditions for IWI-S route 1) WTE-S WIE-S PE-S
Candidates to IWI-C	WTE-B + WTE-S + WTE-C WIE-B + WIE-S + WIE-C PE-S + PE-C	WIE-B+ WIE-S + WIE-C PE-S + PE-C	WTE-C WIE-C PE-C

Table 1 – Examinations to be passed in relation to level and qualification route

In order to pass each exam (WTE, WIE and PE), candidates must achieve at least 60% of the maximum total score in each exam.

In the specif case of the Pratical Exam (PE) candiates to pass must achieve at least 60% of the maximum total score, and a minimum of 50% of the maximum score for each part of the exam (see item 7.3, Table 2).

The examination shall be completed within a period of three years from the first exam.

In case the examins refer to standards, the related standards shall be made available to the examinee.

7.1 WTE: WT examination

This part will examine the candidate's knowledge only regarding the welding Technology Module.

The examination will consist of a harmonised examination and a national examination.

The international harmonised examination is ruled by IAB OP 17[1].
At the discretion of the ANB the national examination shall consist of:

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

The exam content shall cover the 4 sub-modules proportionally to the duration of each training module. Minimum requirements for the duration of the examination is given in table 2.

[1] According to the current revision of IAB OP 17, the scoring of the international harmonised examination may not be used to score the exams of candidates; however it is expected that using the scoring of the harmonized examination will be compulsory, at a later date.

7.2. WIE: WI examination

This part will examine the candidate's knowledge only regarding the welding Inspection Module. The examination will consist of a harmonised examination and a national examination.

The international harmonised examination is ruled by IAB OP 17[2].

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

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

The exam content shall cover the 2 sub-modules proportionally to the duration of each training sub-module.

7.3. PE: Practical exams

The extent of the practical exams is given in table 2.

For Basic and Standard levels exams, this is a written examination of the candidate's practical capabilities of performing the welding inspection tasks the way they were taught during the course. This examination is composed of several parts, as follows:

- Basic level, 8 parts;
- Standard level, 11 parts.

For Comprehensive level exam, this is an oral examination in the form of a professional interview of the candidate's practical capabilities of performing the welding inspection tasks the way they were taught during the course. The examination is composed of only one part.

Appendix III specifies requirements for each part of the practical exams.

[2] According to the current revision of IAB OP 17, the scoring of the international harmonised examination may not be used to score the exams of candidates; however it is expected that using the scoring of the harmonized examination will be compulsory, at a later date.

LEVEL OF QUALIFICATION / CONTENT (DURATION)		
PE-B	**PE-S**	**PE-C**
Conduct of Visual Testing + reporting against acceptance criteria, (2 fillets or 1 butt weld(*))	Conduct of Visual Testing + reporting against acceptance criteria, 2 specimens (1 fillet and 1 butt weld) (*)	-
Evaluation of bend testing specimens(**) related to welder approval	Evaluation of bend testing specimens(**) and fracture testing (***) related to welder approval	-
Evaluation of fracture testing specimens (***)related to welder approval	Evaluation of fracture testing specimens (***)related to welder approval	
Review of one material test certificate (Raw/base/parent or filler)	Review of 2 Test Certificates (Raw/base/parent material, filler material)	-
Interpretation of two Macrographs (**)	Interpretation of two Macrographs (**)	-
	Review of 2 Destructive test reports from tensile, hardness, impact/Charpy	-
Review of 2 NDT reports (PT, MT, RT, UT,)	Review of 1 NDT report from PT, MT, RT and UT (4 in total)	-
Review of one Welder's qualification test certificate	Review of one Welder's qualification test certificate	-
	Review of 2 RT Images for assessment of quality****	-
WPS Review (case study)	WPQR Compliance (Case study)	-
	WPS compliance against WPQR	
		Case study with professional interview*****
* Harmonised plastic specimen, to be used within a defined period of time ** Harmonised Photographs, to be within a defined period of time. *** Harmonised plastic specimen (to be investigated), to be used within a defined period of time **** Harmonised images, to be used within a defined period of time ***** Based on Harmonized situations		

Table 2 – Practical Exams (parts and overview)

7.4. Duration of the examinations

The minimum duration for each part of the examination is reported in Table 3.

EXAM	Time (hrs)
IWS 0 examination	See IAB 252
WTE-B	2
WTE-S	1,5
WTE-C	1,5
WIE-B	2
WIE-S	1,5
WIE-C	1,5
PE-B	2
PE-S	4
PE-C	2,5

Table 3 – duration of the Examinations

The duration of the WTE and WIE harmonised examination is always a part of the total time abovementioned 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.

8. Re-examination

Failure in one examination shall require re-examination only in the part failed. Each examination must be retaken within 2 weeks to 15 months of the initial examination and, in the case of a second failure, one further attempt is permitted within 1 to 15 months from the date of the second examination. If a candidate fails three times he/she has to retake the classes of the module failed and then retake the relevant examination.

For all Routes, if the candidate fails the Welding Technology examination twice at the appriopriate level, having exercised an option to proceed directly to that examination, he/she must undertake the omitted training module before re-sitting the examination failed.

9. Diploma of the International Institute of Welding

After successful examination an International Institute Welding Diploma, corresponding to the examined level, is awarded to the candidate by the Authorised Nominated Body.

10. Appeals procedure

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

11. Transition arrangements

All National Transition Arrangements are published on the IAB Transition Arrangements Directory, doc. IAB-021 in its latest revision.

Each country's specific Transition Arrangements are approved by the IAB Group B and may be obtained from each Authorised Nominated Body.

Appendix I: Requirements for ANBs and ATBs to run the training courses

1. Equipment

It is recommended that ATBs allow access to the equipment and tools as listed in the following paragraphs. All the equipment used for the courses must be in good working order and fit for its purpose.

1.1 Welding equipment

Equipment for the following processes must be available for demonstration:

- Manual metal arc welding - 111
- MIG welding - 131
- MAG welding – 135/136
- TIG welding - 141
- Gas welding - 311

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

1.2 NDT equipment:

Equipment for the following methods must be available for demonstration and/or practical work. The minimum number of pieces of equipment is shown in brackets.

- Ultrasonic flaw detectors (One set, only for demonstration)
- X-ray or Y-ray equipment (One set, only for demonstration)
- Radiographic film viewers (Two persons per viewer)
- Magnetic particle testing equipment (four persons per set)
- Liquid penetrant testing equipment (four persons per set)

1.3 Measuring instruments

Weld size gauges, magnifying glasses, rules, angle protractors and other appropriate equipment must be available for visual inspection exercises.

2. Specimens

A range of weld specimens containing appropriate defects for practical NDT exercises must reflect the range of joint types found in practice, such as butt joints in plate, T-joints, nozzles, pipes and branches. The defects must be fully recorded in control diagrams.

A range of weld specimens for visual inspection must also be available containing surface and surface breaking defects.

Weld cross sections containing defects, polished and etched, should be available to demonstrate the types of defect found in welds made by the processes listed in item 1.1 above.

Specimens for mechanical testing should be available reflecting tests applicable to welded joints in different conditions

3. Radiographic images

A collection of radiographs (films or digital images) covering a range of applications must be available for practical work on radiographic interpretation.

Appendix II: ANB detailed assessment

After the candidate has fulfilled the requirements of the ANB check, he will be admitted to the ANB detailed assessment.

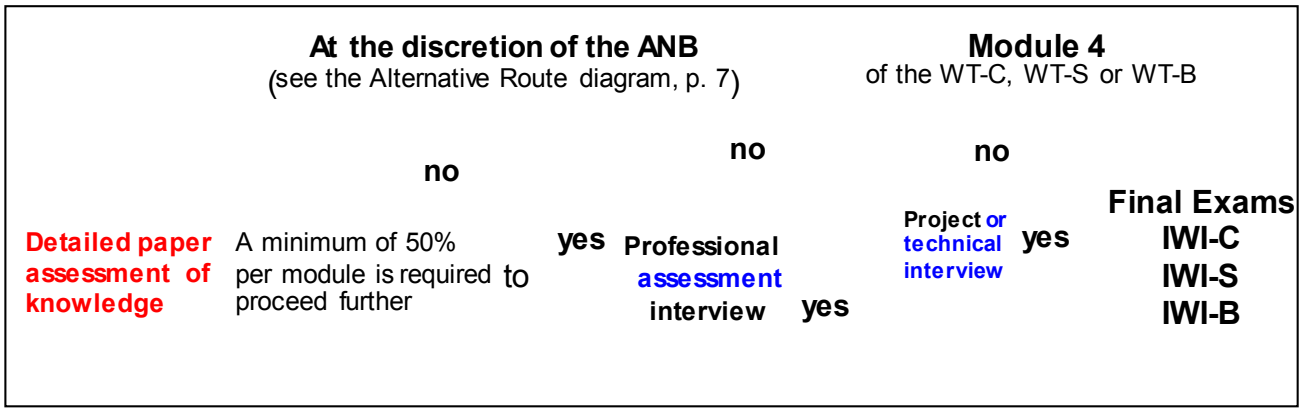


Figure 4: ANB detailed assessment

The full ANB detailed assessment shall contain:

- a detailed paper assessment of knowledge (checklist with points)
- a professional assessment interview designed to test understanding and ability to reason in the field of welding and the syllabus of the standard course and
- a project or a technical interview to test logical application of knowledge

The sequence of this assessment shall be determined by the ANB. It is at the discretion of the ANB to terminate the assessment and send the candidate back or into the standard route.

If he/she has a diploma of IIW (IWE, IWT, IWS, or IWP) or an ANB approved national certificate of welding co-ordination[3], and valid NDT certificates in compliance to ISO 9712 which cover the syllabus of the Welding Inspection Modules of the present Guideline, he/she can proceed to the professional assessment interview for the equivalent level of qualification without a detailed paper assessment.

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

For Welding Technology modules:
Frames of requirements:

	Max. No. of points		
	IWI-C	IWI-S	IWI-B
Module 1: Welding processes	10	8	8
Module 2: Materials and their….	13	12	10
Module 3: Construction and design	10	9	8
Module 4: Fabrication, applications engineering	8	8	8
∑ =	41	37	34

[3] ANB approved National certificate of welding coordination means certificate content is based on ISO 14731 and issued by a body accredited to ISO 17024.

The detailed points are distributed as following:

Module 1: Welding processes

111 - MMA	2 points	2 points	2 points
141 - TIG and 15 - Plasma	2 points	2 points	2 points
131 MIG 135 MAG	2 points	2 points	2 points
114, 136 and 137 - Flux-cored methods	1 point	1 point	1 point
91, 93 and 97 - Brazing methods	1 point	0,5 point	0 point
81, 82 and 83 - Thermal cutting	0,5 point	0,5 point	1 point
12 - SAW	1 point	0 points	0 points
Other methods	0,5 point	0 points	0 points
∑ =	10 points	8 points	8 points

Module 2: Materials (acc. to CR ISO/TR 15608) and their behaviour during welding

Steel alloys -	groups 1 – 3 and 11	3 points	3 points	3 points
Cr-Mo- and vanadium steels:	groups 4 - 6	2 points	2 points	2 points
Ferritic and martensitic steels	group 7	3 points	2 points	2 points
Austenitic and aust./fer. steels	groups 8 and 10	1 point	1 point	1 point
Steel-Ni- alloys, max 10% Ni	group 9	1 point	1 point	1 point
Aluminium and alloys	groups 21 - 26	1 point	1 point	1 point
Nickel and alloys	groups 41 - 48	1 point	1 point	0 point
Cast iron	groups 71 - 76	1 point	1 point	0 point
	∑ =	13 points	12 points	10 points

Module 3: Construction and design

Stresses and strains	3 points	3 points	2 points
Design of welded structures - static loading	1 point	1 point	2 points
Design of welded structures - dynamic loading	1 point	1 point	1 points
Joint design & design principles of welded structures	3 points	2 points	2 points
Design of structures of aluminium and its alloys	2 points	2 points	1 point
∑ =	10 points	9 points	8 points

Module 4: Fabrication, applications engineering

Quality assurance in welded fabrication	1 point	1 points	1 points
Quality control during manufacture	2 point	2 points	2 points
Welding stresses and distortion	1 point	1 point	1 point
Plant facilities, welding jigs and fixtures	1 point	1 point	1 point
NDT	1 point	1 point	1 point
Repair welding	1 point	1 point	1 point
Health and safety	1 point	1 point	1 point
∑	= 8 points	8 points	8 points

As a minimum, each applicant must achieve 50% in each module for IWI-C, S and B, to be admitted to the professional interview.

For Welding Inspection modules:

The detailed points are distributed as following:

	IWI-C	IWI-S	IWI-B
1. General introduction to welding inspection	1 points	1 points	1 point
2. Testing	2 points	2 points	2 points
3. Weld Imperfections	3 points	2 points	2 points
4. Testing methods	10 points	8 points	8 points
5. Quality Assurance	2 points	2 points	1 point
6. Managements of inspection function	2 points	2 points	0 point
7. Practical work	8 points	6 points	6 points
$\sum$ =	28 points	23 points	20 points

As a minimum, each applicant must achieve 50% in Modules 1 to 7 for IWI-C, S and B, to be admitted to the professional interview.

b) Professional assessment interview

The professional interview is designed to test understanding and ability to reason in the field of welding regarding the IIW relevant Guideline syllabus:

The Professional interview duration must be at least:		
IWI-C	**IWI-S**	**IWI-B**
45 minutes	30 minutes	30 minutes

For a candidate reaching > 75% of the maximum possible points in the paper assessment, he/she may be exempted from the professional assessment interview in that module. However, the minimun total time shall be not less than half of the time stipulate for the relevant Guideline.

If the ANB decides that the candidate should leave the detailed assessment after the professional assessment interview but before the project or the technical interview, the candidate, as a minimum, has to go through Module 4 of the WT III, WT II or WT I of the standard route. After the candidate has attended Module 4, he/she is allowed to perform the final exams.

c) Project or technical interview

The ANB offers each candidate the option of a project with a project final report including an oral review of the project report and a practical part **or** to be assessed via a technical interview. Each of the assessment routes are explained below.

c.1) Project

In the project, a case study (designed for 60 hours for IWI-C, 40 hours for IWI-S and 20 hours for IWI-B) with a duration of a maximum of four, three and two weeks respectively, must be done alone. Where a project has a wide scope of application, the candidate shall be tested on the logical application of his/her knowledge.

The ANB offers a choice of construction/fabrication, to be in accordance with an approved national or international code and/or product standard. One of the following constructions shall be selected:

- Pressure vessel
- Construction - static loading
- Construction - dynamic loading
- Other construction

When a model of the project work has been detailed, the ANB shall decide in each case, the specific items to be covered by the candidate.

SUBJECTS	IWI-C	IWI-S	IWI-B
Drawings	**2**	**2**	**1**
Establish that the manufacturer / repairer is working to approved drawings	X	X	X
Verification that the design of all parts of the fabrication, repairs and modifications are in accordance with the requirements of the applicable approved code	X		
Quality plans	**6**	**2**	**1**
Verify that the quality plan is approved by manufacturer or repairer, client and inspection authority.	X	X	X
Sign and complete the inspection stage requirements of the inspection authority.	X	X	X
Verification that an agreed quality plan is to be implemented. Incorporation of inspection requirements for witness, hold and surveillance points.	X		
Materials	**12**	**6**	**5**
Correlation of material certificates with materials of construction and checking conformity of material specification	X	X	X
Identification of material and witnessing of transfer identification	X	X	X
Visual examination of material, cut edges and heat affected zones.	X	X	X
Welding procedures	**6**	**4**	**2**
Approval of welding procedures.	X		
Verify that applicable approved welding procedures are being used and followed.	X	X	X
Witnesses the production procedure test plates, the mechanical testing of test pieces prepared from the plates, evaluates the results and validates applicable reports.	X	X	X
Welder approvals	**8**	**6**	**4**
Approval of welders and operators	X	X	X
Examine fit-up of joint for welding.	X	X	X
Verify second results of dimensional checks. Examine weld preparations and tack welds	X	X	X
Inspect the back side of the weld after the face side is completed and root cleaned	X	X	X
Testing	**16**	**4**	**5**
Examine and accept non-destructive test reports.	X	X	
Verify compliance with agreed procedure and acceptability of any defects	X	X	
Evaluate radiographs and accept or reject components on such evaluation.	X	X	
Verify NDT personnel qualifications.	X	X	
Verify defects reported by NDT personnel as to their capability against a code.	X	X	
Examine NDT procedures, techniques, sheets and/or reports for compliance as having being signed / authorised by the recognised competent personnel.	X	X	
Witness and evaluate mechanical testing of production test welds	X	X	
Examine heat treatment records and verify compliance with procedure.	X	X	

SUBJECTS	IWI-C	IWI-S	IWI-B
Witness that pre-and post heat treatments are performed in accordance with approved procedures if this requirement is included in the quality plan.	X	X	X
Witness the pressure test if required and verify code requirements.	X	X	X
If required, record the amount of permanent set.	X	X	X
Visually examine the completed fabrication or the repair / modification area, as relevant, internally and externally	X	X	X
Witness dimensional checks made by the manufacturer or repairer. Controlled against drawing requirements.	X	X	X
Verify if required marking of nameplate details and attachment of plate to fabrication.	X	X	
Heat treatment	**2**	**2**	
Examine heat treatment records and verify compliance with procedures	X	X	
Documentation	**8**	**4**	**2**
Collation of documentation	X	X	
Verify collation of documentation for data book or repair report.	X	X	X
Sign construction and test certificate or record of continuance.	X	X	
Verify certification details and co-sign certification with the manufacturer or repairer	X	X	X

c.2) Technical Interview

Technical interview duration is at least:		
IWI-C	**IWI-S**	**IWI-B**
4 hours	3 hours	2 hours

The technical interview will be divided into 2 parts, these are:

Part 1: Discussion wIth the applicant regarding evaluation of the applicant's knowledge of the project construction/fabrication (See table below).

Part 2: Discussion with the applicant regarding evaluation of the applicant's practical knowledge (See table below).

Before the technical interview, the candidate is given at least 1 hour to become familiar with the documentation that will be used during the interview.

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

or

The applicant presents a set of documents (construction drawings - part of a construction, list of materials, material certificates, NDT reports, destructive testing reports, WPQRs, WPSs, Welder approvals). These documents should be from the company where the applicant is currently employed. These documents must be initially evaluated by the ANB before being accepted as documentation to be used in the applicant technical interview.

The technical interview shall address as a minimum, the subjects mentioned in the tables below. The candidate will be admitted to the final examination **only after** fulfilling all of the requirements for a and b and c.1 or c.2 of the ANB detailed assessment.

Part 1 – Evaluation of the applicant's knowledge of the project construction/fabrication

Subjects	IWI-C	IWI-S	IWI-B
Evaluation of drawings and technical specifications.	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		
Knowledge about the choice of base materials. Discuss the weldability of the materials. Any needs for pre- and post weld heating.		X	X
Evaluation and discussion of the construction based on the choice of:			
- Joining method(s) for the base material(s);	X	X	X
- Cutting method(s) for preparation of base material parts	X	X	X
- Joint preparation and weld calculation	X	X	
- Joint preparation			X
- Welding consumables;	X	X	X
- Need of surface treatment before welding;	X	X	X
- Surface treatment of finished construction - method(s) to be used.	X		
Preparation of necessary WPSs and testing methods.	X	X	
Interpretation of necessary WPSs.			X
Evaluation of necessary welding qualification(s) for welder(s).	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	
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	
- Standards needed for the project;	X		
Discussion on the construction			
- 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	
- Jigs, fixtures, welding equipment	X	X	X

Part 2 – Practical discussion

Subjects	IWI-C	IWI-S	IWI-B
Checking:			
- Certificate(s) on base material(s);	X	X	X
- Welder(s) qualification test certificate(s);	X	X	X
- Qualification of personnel for destructive testing, NDT and inspection	X	X	
- Welding Procedure Qualification Record - WPQR;	X	X	
- Welding Procedure Specification - WPSs;	X	X	X
Evaluation of test results and discussion of the reports.	X	X	
Proposal for a plan for inspection before, during and after welding and discussion.	X	X	
Discussion of inspection reports.			X
Evaluation of the welding and test results based on inspection and NDT reports.	X	X	
Welds needing repair, plan(s) for repair welding and eventually, WPSs for repair welding to be made.	X	X	

Appendix III: Requirements for practical exams

Practical exams have been designed to test Candidates capabilities in preforming welding inspection activities.

The following requirements apply for the Examination room:
- During Visual inspection, lighting contions shall be in conformance with ISO 17637;
- Exam desks shall ensure that candidates have room enough to manage the weld specimens, gauges and paper;
- Environmental conditions (noise, other) shall be in accordance with the requirements of IAB-001 (latest revision)

The following paragraphs report specific requirements for the different part of the practical exams, according to Table 2, Paragraph 7.3, Section II. All the materials for the practical exams are harmonised. ANBs shall use the harmonized specimens, the specific instructions and master answer sheets to conduct and to score the examinations.

Practical examination at the Basic and Standard levels is composed of three parts:
- **Part a** - Visual testing of welds (see paragraph 1);
- **Part b** - Review of welding related documents: WPS, WPQR, Welder approvals (see paragraph 2);
- **Part c** – Other inspection tasks (see paragraph 3).

The candidate will pass the examination if reaching at least 60% of the total scoring and 50% for all the parts of the examination. Candidate failing on a single part, are allowed to undertake re-examination on the part failed only.

Practical examination at the Comprehensive level consists of a written examination and professional interview (see paragraph 4)

1. Part a - Visual testing of welds

1.1 Specimen to be provided to the candidates by the ANB:

The candidate shall be provided with:
- harmonised plastic specimen(s), type and number of weld joints are referenced in Section II, Item 7.3, table 3;
- Each specimen shall have a master report;
- In the exam group the ANB should use a number of different specimens to avoid the candidates adjacent to one another using the same specimens.

1.2 Tools and equipment to be provided to the candidates by the ANB

The candidate shall be provided with:
- A set of weld gauges capable of measuring the weld reinforcement, undercuts, fillet legs, or weld throat and misaligment;
- Ruler or tape measure;
- A Vernier
- Magnifying lens

1.3 Documentation to be provided to the candidates by the ANB

During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Exam instruction sheet for the visual inspection where the goal of the exam is defined including the accpetance criteria level, etc.
- Acceptance criteria standards ISO 5817;
- Blank test report;

1.4 Task for examination

Candidate shall conduct visual testing of fillet and/or butt weld (see part II, item 7.3, table 2) according to ISO 17637. Candidates shall evaluate the specimen by identifying imperfections according to ISO 6520, measuring imperfection and evaluating acceptability according to ISO 5817, level C. Results of testing shall be reported by means of test report completed by candidate.

1.5 Scoring

Each candidate will have to identify 4 imperfections detected among those available on the specimen; based on those imperfections, scoring will be based on identification, measuring and evaluation of acceptance as follows.

Score	Identification	Measuring	Acceptance
0	N	n.a.	n.a.
1	Y	N	n.a.
2	Y	Y	N
6	Y	Y	Y
Y: Correct, N: Wrong, n.a.: Not applicable			

Table 1 – scoring of visual examination test

2. Part b - Review of welding related documents: WPS, WPQR, Welder approvals

2.1 WPS review

2.1.1 WPS specimens to be provided to the candidates by the ANB

WPS specimens shall be harmonized; in addition, the following requirements apply

- Candidates have to reviview the technical content of the WPS (e.g. incorrect information, omissions, conflicting or inconsistent information, etc.);
- Each candidate will mark the mistakes/omissions on the written copy of the WPS
- In the exam group the ANB should use a number of different specimens to avoid the candiates adjacents to one another using the same specimens

2.1.2 Tools and equipment to be provided to the candidates by the ANB

No specific tool or equipment is required.

2.1.3 Documentation to be provided to the candidates by the ANB

During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:

- Exam instruction sheet.

2.1.4 Task for examination

Candidates have to reviview the technical content of the WPS (e.g. incorrect information, omissions, conflicting or inconsistent information, etc.).

2.1.5 Scoring

Scoring is based on the following criteria:

- Each correct finding is scored 2;
- Each incorrect finding is scored -1;
- Minumum scoring is 0.

2.2 Welder's qualification test certificate evaluation

2.2.1 Specimens to be provided to the candidates by the ANB:
Welder approval certificate shall be harmonised; the following requirements apply:
- The welder approval certificate specimens are prepared according to the standard ISO 9606-1;
- Each candidate will mark the mistakes/omissions/incongruences on his printed copy of the specimen (certificate)
- In the exam group the ANB should use a number of different specimens to avoid the candiates adjacents to one another using the same specimens

2.2.2 Tools and equipment to be provided to the candidates by the ANB
No specific tool or equipment is required.

2.2.3 Documentation to be provided to the candidates by the ANB:
- Exam instruction sheet;
- ISO 9606-1 Standard

2.2.4 Task for examination
Candidates shall identify mistakes/omissions/incongruences.

2.2.5 Scoring
Scoring is based on the following criteria:
- Each correct finding is scored 2;
- Each incorrect finding is scored -1;
- Minumum scoring is 0.

2.3. WPQR compliance to standard

2.3.1 WPQR specimens to be provided to the candidates by the ANB
WPQR specimens shall be harmonized, in addition the following requirements apply
- Candidates have to verify WPQR compliance with the ISO 15614-1 standard;
- Each candidate will mark the mistakes/omissions on the written copy of the WPQR.
- In the exam group the ANB should use a number of different specimens to avoid the candiates adjacents to one another using the same specimens

2.3.2 Tools and equipment to be provided to the candidates by the ANB
No specific tool or equipment is required.

2.3.3 Documentation to be provided to the candidates by the ANB
During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Exam instruction sheet;
- Standard - ISO 15614-1.

2.3.4 Task for examination
Candidates have to verify WPQR compliance with ISO 15614-1

2.3.5 Scoring
Scoring is based on the following criteria:
- Each correct finding is scored 2;
- Each incorrect finding is scored -1;
- Minumum scoring is 0.

2.4. WPS compliance against WPQR

2.4.1 WPS and WPQR specimens to be provided to the candidates by the ANB
WPS and WPQR specimens shall be harmonized, in addition the following requirements apply
- Examination is based on 1 WPS with non-compliances to a reference WPQR (excerpt)
- Each candidate has to find all the mistakes by marking on the WPS
- In the exam group the ANB should use a number of different specimens to avoid the candiates adjacents to one another using the same specimens

2.4.2 Tools and equipment to be provided to the candidates by the ANB
No specific tool or equipment is required.

2.4.3 Documentation to be provided to the candidates by the ANB
During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Exam instruction sheet;

Standard - ISO 15614-1

2.4.4 Task for examination.
Candidates have to find all the mistakes by referring to the excerpt of the provided WPQR by marking the errors on the WPS.

2.4.5 Scoring
Scoring is based on the following criteria:
- Each correct finding is scored 2;
- Each incorrect finding is scored -1;
- Minumum scoring is 0.

3. Part C – Other inspection tasks

3.1. Evaluation of Bending specimens

3.1.1 Specimen to be provided to the candidates by the ANB
Each specimen shall be a set of two harmonised photographs (top and lateral view) with the related reports. In addition in the following requirements apply
- Two bend specimens as it is refered in Section 2, Item 7.3, table 2
- In the exam group the ANB should use a number of different specimens to avoid the candidates adjacents to one another using the same specimens

3.1.2 Tools and equipment to be provided to the candidates by the ANB :
No specific tool or equipment is required.

3.1.3 Documentation to be provided to the candidates by the ANB
During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Exam instruction sheet for the evaluation of bend specimen where the goal and acceptance criteria of the exam are defined;
- Acceptance criteria standard ISO 9606-1.

3.1.4 Task for examination.
The candidate shall evaluate the acceptability of the bending test and of the possible flaws

3.1.5 Scoring
Scoring is based on the following table

Score	Acceptability of bending test	Acceptability of flaws
0	N	n.a.
1	Y	N
3	Y	Y
Y: Correct, N: Wrong, n.a.: Not applicable		

Table 2- Scoring for “evaluation of bending specimens test”

3.2. Evaluation of Material Test Certificates (MTC)

3.2.1 MTC Specimen to be provided to the candidates by the ANB
The candidate shall be provided with Material Test Certificates (MTC) according to the following requirements:
- The MTC specimens shall be the harmonised specimens, consisting of a material test certificate, a material specification, a case study and a set of questions related to the provided documents;
- The number of specimens is defined in Part II, Item 7.3, table 2.
- In the exam group the ANB should use a number of different specimens to avoid the candiates adjacents to one another using the same specimens

3.2.2 Tools and equipment to be provided to the candidates by the ANB :
No specific tool or equipment is required.

3.2.3 Documentation to be provided to the candidates by the ANB
During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Material test certificate(s)
- Material specification(s)
- Case study(ies)
- A set of questions related to the provided documents;

3.2.4 Task for examination
The candidate shall answer 5 multiple choice questions, each with only one correct answer out of 4.

3.2.5 Scoring
Each correct answer is scored 1.

3.3 Interpretation of Macros

3.3.1 Macro prohtographs to be provided to the candidates by the ANB
The candidate shall be provided with 2 Macro Photographs and instructions according to the following requirements:
- The Macro photographs shall be the harmonised specimens;
- The first Macro will be used to determine acceptability
- The second macro will be used for a set of three questions
- In the exam group the ANB should use a number of different specimens to avoid the candiates adjacents to one another using the same specimens

3.3.2 Tools and equipment to be provided to the candidates by the ANB:
The candidate shall be provided with:
- Ruler and protractor.

3.3.3 Documentation to be provided to the candidates by the ANB
During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Exam instruction sheet for the evaluatuion of the macros
- Acceptance criteria standards ISO 5817;
- Master report sheets for the first macro photgraph;
- A set of questions for the second macro photograph.

3.3.4 Task for examination
For the first macro the candidate has to verify acceptability against ISO 5817 level C, based on two detected imperfections.
For the second macro the candidate has to answer three multiple choice questions having 1 correct answer out of 4.

3.3.5 Scoring
For the first Macro, scoring is based on two detected imperfections, as reported table 3.

Score	Identification (based on numbering)	Measuring	Acceptance
0	N	n.a.	n.a.
1	Y	N	n.a.
2	Y	Y	N
4	Y	Y	Y
Y: Correct, N: Wrong, n.a.: Not applicable			

Table 3 – Scoring system for the first Macro

For the second Macro each correct answer is scored 2.

3.4 Evaluation of Fracture specimens

3.4.1 Specimen to be provided to the candidates by the ANB
The specimen shall be one harmonised plastic specimens. In addition in the exam group the ANB should use a number of different specimens to avoid the candidate's adjacents to one another using the same specimens.

3.4.2 Tools and equipment to be provided to the candidates by the ANB :
No specific tool or equipment is required.

3.4.3 Documentation to be provided to the candidates by the ANB
During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Exam instruction sheet for the evaluation of fracture specimen where the goal of the exam and acceptance criteria is defined;
- Acceptance criteria standards ISO 9606-1.

3.4.4 Task for examination.
The candidate shall verify the acceptability as related to lack of penetration/fusion.

3.4.5 Scoring
Scoring is two points for the correct answer.

3.5. Destructive test reports evaluation

3.5.1 Destrcutive test reports specimens to be provided to the candidates by the ANB

Destructive test reports specimens shall be harmonised; in addition, the following requirements apply:
- Candidates will receive 2 specimens referring to two different destructive reports among Tensile, Hardness, Impact/Charpy;
- Each candidate will mark the mistakes/omissions on the written copy of the report
- In the exam group the ANB should use a number of different specimens to avoid the candiates adjacents to one another using the same specimens

3.5.2 Tools and equipment to be provided to the candidates by the ANB:
No specific tool or equipment is required.

3.5.3 Documentation to be provided to the candidates by the ANB:
During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Exam instruction sheet.

3.5.4 Task for examination.
Candidates shall identify mistakes/omissions

3.5.5 Scoring
Scoring is based on the following criteria:
- Each correct finding is scored 2;
- Each incorrect finding is scored -1;
- Minumum scoring is 0.

3.6. Non Destructive test reports evaluation

3.6.1 Non Destructive test reports specimens to be provided to the candidates by the ANB
The Non destructive test reports shall be harmonised; the following requirements apply:
- Requirement for the number of specimens is reported in Section II, item 3.1, table 2;
- Each specimen shall refer to a different test method
- Each candidate will mark the mistakes/omissions on the written copy of the report
- In the exam group the ANB should use a number of different specimens to avoid the candiates adjacent to one another using the same specimens

3.6.2 Tools and equipment to be provided to the candidates by the ANB:
No specific tool or equipment is required.

3.6.3 Documentation to be provided to the candidates by the ANB
During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Exam instruction sheet

3.6.4 Task for examination
Candidates shall identify mistakes/omissions/incongruences

3.6.5 Scoring
- Each correct finding is scored 2;
- Each incorrect finding is scored -1;
- Minumum scoring is 0.

3.7. RT films quality evaluation

3.7.1 RT radiographic specimens to be provided to the candidates by the ANB
RT Film specimens shall be harmonized; the following requirements apply

- 2 RT films/images (1 RT from a plate, 1 RT from a tube);
- Each film/image is connected with an information sheet; this information isto be checked against a reference specification (4 items each)
- In the exam group the ANB should use a number of different specimens to avoid the candiates adjacents to one another to using the same specimens
- candidates shall avoid possible damage of the films during the examination by taking suitable preventative measures, e.g waring cotton gloves

3.7.2 Tools and equipment to be provided to the candidates by the ANB:
Based on the type of image, the candidate shall be provided with:
- Films: Film viewer (Negativoscope) and a Densitometer

Or
- Digital images: Tablet/PC with a mimimum size of the screen of 8".

3.7.3 Documentation to be provided to the candidates by the ANB
During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Exam instruction sheet
- Film/Image
- For each Film/Image a technical information sheet (used also as answer sheet);
- Quality films/image specification

3.7.4 Task for examination
Verify the information provided and the image againse the film/image specification.

3.7.5 Scoring
Each film/image is scored 1.

4. Case Study with professional Interview (only for IWI-C)

4.1 Specimens to be provided to the candidates by the ANB

Examination is based on a harmonized project file and shall include:
- quality requirements for the manufacturing (sub-contracting not allowed),
- drawing with specification of acceptance criteria, type and extension of NDT,
- list of materials and materials map,
- Weld Map with list of WPS and WPQRs,
- list of welders/operators with relevnt certification designation (according to ISO 9606-1) and the validity period,
- 4 WPSs,
- quality/inspection testing plan,
- list of available facilities,
- list of equipment including calibrated equipment,
- list of available NDT personnel certification.

In addition the following requirements apply
- Each candidate will have to sit a written examination and a professional interview;
- In the exam group the ANB should use a number of different specimens to avoid the candiates adjacent to one another using the same specimens

4.2 Tools and equipment to be provided to the candidates by the ANB

No specific tool or equipment is required.

4.3 Documentation to be provided to the candidates by the ANB

During the examination, candidates shall have access to the following documents, to be provided by the ANB for examination purposes:
- Project file;
- Exam instruction sheet.

4.4 Task for the examination.

4.4.1 Written examination
The candidate has to identify mistakes, incongruences and omissions by marking on the documents of the file and to answer three essay questions, addressed at specific situations.
Duration of the harmonized examination part is 1,5 hour.

4.4.2 Professional interview
The professional interview is based on the project file; the interview will cover the candidate's understanding of and ability to interpret applicable quality requirements and the quality aspects of welding fabrication, and quality related documentation.
The harmonized examination consists of a check list of subjects to be addressed by the examinee during the professional interview; evaluation criteria are provided to the ANBs (e.g. technical knowledge, communication skills, use of appropriate terms and vocabulary, etc.)
Duration of this part is minimum 1 hour

4.5 Scoring

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

The final rate for approval shall be at least 60% of the average scoring (written and professional interview).

4.5.1 Written examination
Total scoring for written examination is based on:
- Marking mistakes, omission and incongruences (each correct finding is scored 2, Each incorrect finding is scored -1, to a minimum of 0) weights 50%, candidates have to achieve at least 50% of the total available points (20 to 24);
- Essay questions weights 50%, candidates have to achieve at least 50% of the essay maximum scoring

4.5.2 Professinal interview
Candidates shall access this part after completion of written examination with a minimum scoring of 60% of the maximum available scoring; border-line cases shall be accepted at the discretion of the Examining Board.
The minimum scoring is 60% of the maximum available scoring; border-line cases shall be accepted at the discretion of the Examining Board.