IIW Guideline for INTERNATIONAL MECHANIZED, ORBITAL AND ROBOT WELDING PERSONNEL

Minimum Requirements for the Education, Training, Examination and Qualification

IAB-348r1-17

MINIMUM REQUIREMENTS FOR THE EDUCATION, TRAINING, EXAMINATION AND QUALIFICATION

INTERNATIONAL MECHANIZED, ORBITAL AND ROBOT WELDING PERSONNEL - IMORWP

International Diploma in Mechanized Welding at the Basic Level (IMW-B)

International Diploma in Orbital Welding at the Basic Level (IOW-B)

International Diploma in Robot Welding at the Basic Level (IRW-B)

International Diploma in Robot Welding at the Comprehensive Level (IRW-C)

International Diploma in Mechanized, Orbital and Robot Welding at the Comprehensive Level (IMORW-C)

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-530-01
Under the authority of the IIW-International Institute of Welding

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Preface

This document is based upon the European Special Course Robot Welding (former Document EWF-530-01), as developed by the European Federation for Welding, Joining and Cutting (EWF), through an Agreement first signed 19 July, 1997, at the Annual Meeting of the International Institute of Welding (IIW) in San Francisco, California, USA and which has been renewed and further developed since then. It has been established in that Agreement that the International Guideline awarding the International Diploma's are equivalent to the European qualification levels and Diploma's.

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

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

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

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

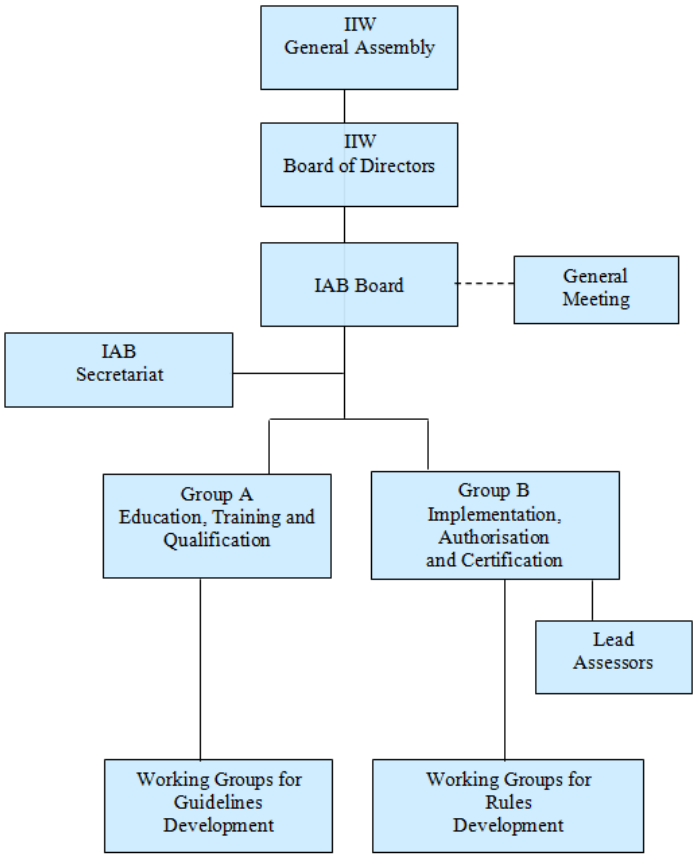


Figure 1: Organisation of the IAB

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

1 Introduction

Section I of the guideline covers the minimum requirements for education and training, which have been agreed upon by all IAB-ANBs, in terms of objectives, scope, expected results, and the teaching hours to be devoted to achieving them. It will be revised periodically by IAB Group A to take into account changes to reflect the "state of the art".

1.1 Guideline Structure

Chapter 2 – Section I - provides an overview of the guideline content.
Chapter 3, of this guideline covers the minimum requirements for education and training; objective, scope and expected results.
Chapter 4 – Section II - of this guideline covers the rules for examination and qualification.

Students having successfully completed modules 1, 2, 3 and 7 of this course and passed the relevant examination (minimum in mechanized, orbital or robot welding or all together) will be expected to be capable of applying the technology required at the “Basic” level in mechanized, orbital or robot welding as covered by this guideline. Students having successfully completed each module of this course of education and passed the appropriate examinations (minimum in mechanized, orbital or robot welding or all together) will be expected to be capable of applying the technology required at the “Comprehensive” level in mechanized, orbital and/or robot welding as covered by this guideline.

The contents are given in the following structure, three routes and two levels and finally five different diplomas. M means mechanized, O means orbital and R means robot welding.

Module	Teaching hours				Required for qualification at the level:	
	IMW	**IOW**	**IRW**	**IMORW**	**B**	**C**
1: Basics of mechanized, orbital and robot welding	8	8	8	8	X	X
2: The quality assurance in mechanized, orbital and robot welding	8	8	8	8	X	X
3: Different welding systems and their programming	12	8	24	44	X	X
4: Design and economy of mechanized, orbital and robot welding systems	-	-	16	16	-	X
5: Design of welded structures for mechanized, orbital and robot welding	-	-	24	24	-	X
6: Case studies	-	-	16	16	-	X
7: Practical education in Comprehensive and (Basic) level	4 (32)	4 (32)	32 (46)	40 -	X	X
TOTAL FOR THE COMPREHENSIVE AND (BASIC) LEVEL	- (60)	- (56)	128 (86)	156 -		

Table 1 – Overview of the Structure of the Training Courses

A “teaching hour” shall contain at least 50 minutes of direct teaching. It is not obligatory to follow exactly the order of the topics given in this guideline and choice in the arrangement of the syllabus is permitted. The depth to which each topic is dealt with is indicated by the number of hours allocated to it in the guideline.

It is to be noted that the overall structure of the syllabus for comprehensive and basic levels is similar, but some items are not considered appropriate in the education of the basic level candidate. This will be reflected in the scope and depth of the examination.

1.2 General Access Conditions

In a separate document (Directory of Access Conditions, latest edition) the national definitions are given in detail.

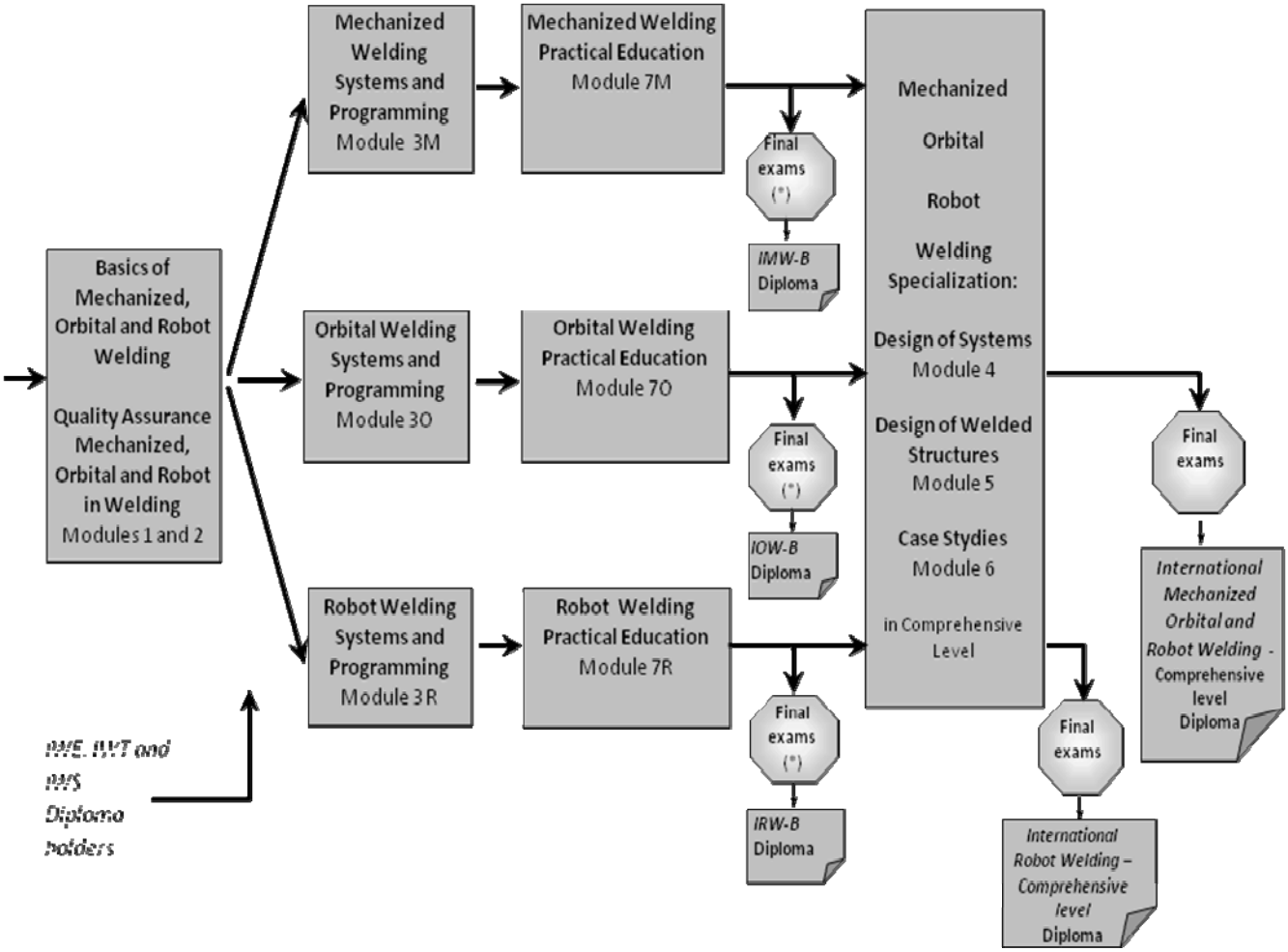
Applicants entering at Comprehensive level shall fulfil at least the National Access Conditions at the IWS level. The purpose of this education concentrates on mechanized, orbital and robot welding technology, with a secondary focus on certain welding processes.

Applicants not fulfilling the access conditions for Comprehensive level may follow the course as a guest but are not allowed entry to the IIW examination at Comprehensive level.

Applicants entering at the Basic level shall fulfil at least the National Access Conditions at the IW Basic level. Applicants should have adequate knowledge of the welding before entering to certain education [this sentence does not have any meaning – ‘adequate’ and ‘certain education’ must be defined]. The purpose of this education concentrates on mechanized, orbital and robot welding technology, with a secondary focus on certain welding processes.

Applicants not fulfilling the entry access conditions at Basic level may follow the course as a guest, but are not allowed entry to the IIW examination at Basic level.

In the case that a participant has an IWE, IWT or IWS diploma, the participant may be exempt from attending the taught modules 1 and 2 but she/he must still take the Module 1 and 2 examinations.



*It includes approval testing of welding operators according to ISO 14732

Diagram 1 - Training modules and levels in education. See also different routes and hours in appendix 1

2 Section I - Course Content Overview:

Theoretical and Practical Education

		Hours
THEORETICAL EDUCATION		
Module 1: BASICS OF MECHANIZED, ORBITAL AND ROBOT WELDING		**8**
(common module for all levels and routes)		
M 1.1	Basics of education for mechanized, orbital and robot welding personnel	2
M 1.2	Mechanization and automation levels in welding	2
M 1.3	Basics of mechanized welding	1
M 1.4	Basics of orbital welding	1
M 1.5	Basics of robot welding	2
Module 2: THE QUALITY ASSURANCE IN MECHANIZED, ORBITAL AND ROBOT WELDING		**8**
(common module for all levels and routes)		
M 2.1	Introduction to quality assurance in welding	1
M 2.2	Quality assurance and quality standards in welding	
	M 2.2.1 Quality standards in welding: EN ISO 3834, ISO 9001, etc	1
	M 2.2.2 Quality control during manufacturing	1
	M 2.2.3 Quality control in mechanized, orbital and robot welding	1
M 2.3	Basics of productivity, quality and economy in welding	2
M 2.4	Qualification of mechanized, orbital and robot welding personnel	2
Specific modules for mechanized (M), orbital (O) and robot (R) welding		
Module 3M: MECHANIZED WELDING SYSTEMS AND PROGRAMMING		**12**
MM 3.1	Structures of mechanized welding equipment and systems	3
MM 3.2	Welding processes for mechanized welding (MIG, MAG, PAW, SAW, TIG)	3
MM 3.3	Joint preparation in mechanized welding procedures	1
MM 3.4	Setting up, welding parameters and programming of mechanized welding systems	2
MM 3.5	Quality assurance in mechanized welding, NDT of welds	2
MM 3.6	Health and safety consideration in mechanized welding	1
Module 3O: ORBITAL WELDING SYSTEMS AND PROGRAMMING		**8**
MO 3.1	Structures of orbital welding equipments and systems	1
MO 3.2	Arc welding processes for orbital welding, TIG cold and hot wire welding and other processes (MIG, MAG, FCAW)	1
MO 3.3	Joint preparation in orbital welding procedures	1
MO 3.4	Material technology and welding metallurgy in orbital welding	1
MO 3.5	Setting up, welding parameters and programming of orbital welding systems	2
MO 3.6	Quality assurance in orbital welding, NDT of welds	1
MO 3.7	Health and safety consideration in orbital welding	1

Module 3R: ROBOT WELDING SYSTEMS AND PROGRAMMING 24

MR 3.1 Basics of robotics and robot welding systems
- MR 3.1.1 Basics of robotics (basics of joint axes robots for welding) 2
- MR 3.1.2 Robot systems 2
- MR 3.1.3 Structures of robot welding systems 2
- MR 3.1.4 Health and safety considerations in robot systems 1

MR 3.2 Robot programming in welding and efficient use
- MR 3.2.1 Arc welding processes for robot welding 2
- MR 3.2.2 Other welding processes for robot welding (resistance, laser) 2
- MR 3.2.3 Programming of robot 2
- MR 3.2.4 Programming of welding robot 2
- MR 3.2.5 Seam tracking systems and sensors in robot welding 1
- MR 3.2.6 Multi robot welding systems 2
- MR 3.2.7 Offline programming and graphic simulation in robot welding 2

MR 3.3 Joint preparation for robot welding 2
MR 3.4 Maintenance 2

For Comprehensive level only

Module 4: DESIGN AND ECONOMY OF MECHANIZED ORBITAL AND ROBOT WELDING SYSTEMS 16

M 4.1 Optimizing of intelligence levels in welding 3
M 4.2 Investment planning of welding systems 3
M 4.3 Design of robot welding systems 3
M 4.4 Lay-out in workshop 2
M 4.5 Efficient implementation of welding systems 3
M 4.6 Economy and productivity in welding systems 2

Module 5: DESIGN OF WELDED STRUCTURES FOR MECHANIZED, ORBITAL AND ROBOT WELDING 24

M 5.1 Design of welded structures for mechanized and orbital welding 4
M 5.2 Design of welded structures for robot welding 8
M 5.3 Preparation for mechanized and orbital welding 2
M 5.4 Preparation for robot welding 3
M 5.5 Design in robot welding jigs and fixtures 4
M 5.6 Best practises of design of welded structures for robot welding 3

Module 6: CASE STUDIES 16

M 6.1 Best practises in welding fabrication and automation 4
M 6.2 Practical cases from industry
- M 6.2.1 Practical cases from industry in mechanized welding 3
- M 6.2.2 Practical cases from industry in orbital welding 3
- M 6.2.3 Practical cases from industry in robot welding 6

Specific modules for mechanized, orbital and robot welding and different contents for Comprehensive and Basic levels

Module 7M MECHANIZED WELDING PRACTICAL EDUCATION

for Comprehensive level	**4**
MM 7.1 Welding demonstrations in mechanized welding	2
MM 7.2 Parameters in welding	1
MM 7.3 Visual examination of welds	1
for Basic level	**32**
MM 7.4 Functional knowledge appropriate to the mechanized welding unit	2
MM 7.5 Knowledge on welding technology	2
MM 7.6 Programming exercises in mechanized welding	8
MM 7.7 Welding exercises in mechanized welding	10
MM 7.8 Qualification tests of the operator	2

Module 7O: ORBITAL WELDING PRACTICAL EDUCATION

for Comprehensive level	**4**
MO 7.1 Welding demonstrations	2
MO 7.2 Parameters in welding	1
MO 7.3 Visual examination of welds	1
for Basic level	**32**
MO 7.4 Functional knowledge appropriate to the mechanized welding unit	2
MO 7.5 Knowledge on welding technology	2
MO 7.6 Programming exercises	8
MO 7.7 Welding exercises	10
MO 7.8 Qualification tests of the operator	2

Module 7R: ROBOT WELDING PRACTICAL EDUCATION

for Comprehensive level	**32**
MR 7.1 Programming exercises of the robots	8
MR 7.2 Programming exercises of welding robots	8
MR 7.3 Off-line programming exercises	16
for Basic level	**46**
MO 7.4 Functional knowledge appropriate to the mechanized welding unit	2
MO 7.5 Knowledge on welding technology	2
MR 7.6 Programming exercises of the robots	8
MR 7.7 Programming exercises of welding robots	16
MR 7.8 Off-line programming exercises	16
MR 7.9 Qualification tests of the operator	2

3 Theoretical and Practical Education (Course Syllabus)

3.1 Module 1: Basics of mechanized, orbital and robot welding 8h

M 1.1 Basics of education for mechanized, orbital and robot welding personnel (2 hrs)

Objective:
The student will understand and will be acquainted with terms, abbreviations, definitions and terminology in welding technology and welding automation.

Scope:
Definitions and terminology related to guideline and welding technology
Content of the guideline
Different modules and levels
Background and definitions

Expected result:
1. Explain the terminology and definitions which are used in this course.
2. Outline the basics of the education.
3. Outline different routes to qualifications.
4. Outline basics of terminology related to welding

M 1.2 Mechanization and automation levels in welding (2 hrs)

Objective:
The student will understand the different mechanization and automation levels from hand welding to adaptive welding, from the lowest level to the highest with adaptive environment. Student will understand the most appropriate application for each level of automation.

Scope:
Manual welding
Semi-automatic welding
Simple mechanization
Intelligent mechanized systems
Pre-programmed automatic welding systems
Robot welding
Automatic welding
Adaptive welding

Expected result:
1. Explain the different mechanization and automation levels.
2. Outline where each level is appropriate and why.

M 1.3 Basics of mechanized welding (1 hr)

Objective:
The student will understand meaning of mechanization in welding and how it helps welder's work. Student will also understand different kind mechanization systems and most used welding processes.

Scope:
Principle of mechanization in welding, simple mechanization
Mechanization possibilities in welding
Welding processes to mechanization

Expected result:
1. Outline the meaning of mechanization in welding.
2. Outline the meaning and selection of mechanization technologies.

M 1.4 Basics of orbital welding (1 hr)

Objective:
The student will understand the meaning of orbital welding, recognize equipment for orbital welding and know the principles of different systems for orbital welding.

Scope:
Principle of orbital welding
Orbital welding equipments (open and close welding headsets)
Orbital welding processes (TIG, other processes)
Narrow gap welding

Expected result:
1. Outline orbital welding technology.
2. Outline orbital welding principles.
3. Outline where to use orbital welding.

M 1.5 Basics of robot welding (2 hrs)

Objective:
The student will understand the meaning of robot welding, recognize the structure of a typical welding robot and know the principles for use of robots in welding.

Scope:
Principle of robot welding
Structure of welding robot
Basics of robot welding systems
Principles of programming of welding robots

Expected result:
1. Outline robot welding technology.
2. Outline basics of robot structure and welding robots.
3. Outline basics of robot welding systems and programming of robots.

3.2 Module 2: The quality assurance in mechanized, orbital and robot welding 8h

M 2.1 Introduction to quality assurance in welding (1 hr)

Objective:
The student will understand the principles of quality assurance and quality control in welding fabrication.

Scope:
Concept of quality assurance and quality control
Quality manual
Quality plan
Personnel and equipment
Inspection
Activities of welding engineer/technologist/specialist in the different function in industry
Activities of IW and operators in the different function in industry

Expected result:
1. Outline the principles of quality assurance, quality control and inspection systems and usage for welding fabrication.
2. Outline basic factors related to personnel and equipment, which influence the quality in welding fabrication.

M 2.2 Quality assurance and quality standards in welding

M 2.2.1 Quality standards in welding: EN ISO 3834, ISO 9001 etc (1 hr)

Objective:
The student will recognise the related standards and their application to welded fabrication as a special process.

Scope:
EN ISO 3834
ISO 9001
Other national and international standards (EN 1090)

Expected result:
1. Interpret appropriate standards for welding quality control.
2. Outline the reason why welding is considered to be a special process and the need for standards for quality control.

M 2.2.2 Quality control during manufacturing (1 hr)

Objective:
The student will understand in detail the requirements and function of quality control during manufacturing.

Scope:
Documentation to national, regional and international standards, e.g. WPS
Advantages to the quality of welded constructions
Welding sequence
Welding coordination and inspection personnel
Welding procedure specification (WPS)

Expected result:

1. Outline the purpose of a WPS.
2. Recognise the main variables for a certain WPS qualification
3. Outline the advantages to the quality of the welded construction

M 2.2.3 Quality control in mechanized, orbital and robot welding (1 hr)

Objective:

The student will understand the meaning of quality control before welding, during welding and after welding. The student will understand also what is most important in quality control before welding.

Scope:

Quality control before welding
Quality control during welding
Quality control after welding

Expected result:

1. Outline the purpose of quality control before, during and after welding.
2. Recognise what is most important in quality control before welding.

M 2.3 Basics of productivity and economy in welding (2 hrs)

Objective:

The student will understand the relationship between productivity and economy in welding.

Scope:

Productivity in welding
Economy in welding

Expected result:

1. Identify principles of productivity in welding.
2. Identify principles of economy in welding.

M 2.4 Qualification of mechanized, orbital and robot welding personnel, ISO 14732 (2 hrs)

Objective:

The student will explain the standards related to welders/operators and welding procedure qualification including traceability, need for calibration and monitoring of welding parameters.

Scope:

Welding operator qualification, ISO 14732
Possible methods of monitoring, control and storage of fabrication data

Expected result:

1. Explain the main purpose of a welding operator qualification and main advantages to the quality of welding fabrication.
2. Interpret the standard for a welding operator qualification, determine the main variables for a particular welding operator qualification and its range of qualification.

Specific modules for mechanized, orbital and robot welding

3.3 Module 3M: Mechanized welding systems and programming 12h

MM 3.1 Structures of mechanized welding equipments and systems (3 hrs)

Objective:
The student will be acquainted with structures and systems for welding when mechanized.

Scope:
Systems where transport of arc is made by moving a torch along the welding groove
Systems using transport of the workpiece relative to the torch
Systems using manipulation of both the workpiece and the torch
Structures of mechanization systems:

- The welding torch mounted directly under the wire feed motor
- The welding control mounted away from the wire feed motor.
- Other equipment which provide automatic fixture travel e.g. side-beam carriages and turning fixtures

Requirements for selection of mechanized welding systems to specific welding case.

Expected result:
1. Outline basics of typical mechanization welding systems.
2. Outline optimal usage of different systems.

MM 3.2 Welding processes for mechanized welding (MIG/MAG, PAW, SAW, TIG) (3 hrs)

Objective:
The student will be acquainted with most common welding processes to mechanized welding, their advantages and disadvantages.

Scope:
Welding processes for mechanized welding:

- MIG/MAG
- PAW
- SAW
- TIG

High productivity processes; twin, tandem, high power processes

Expected result:
1. Outline basics of typical welding processes for mechanized welding.
2. Outline advantages and disadvantages in each process in mechanization.

MM 3.3 Joint preparation in mechanized welding (1 hr)

Objective:
The student will be acquainted with different joint and edge preparation technologies and the importance of accuracy for mechanized welding quality.

Scope:
Survey of edge preparation processes
Accuracy and tolerances of joint preparation

Mechanical joint preparation systems:
- mechanical saw
- mechanical lathe
- bevelling machines

Principles of flame and flame powder cutting
Fundamentals of plasma cutting
Fundamentals of laser cutting

Expected result:
1. Outline main joint preparation systems.
2. Outline joint preparation accuracy.

MM 3.4 Setting up, welding parameters and programming of mechanized welding systems (2 hrs)

Objective:
The student will be acquainted with programmable parameters and other factors that influence weld quality.

Scope:
Setting up in different welding processes and welding systems
The aspects which will be taken account:
- arc length
- magnitude and pulse frequency of the welding current
- welding speed
- inert shielding gas
- parent material
- filler material
- weld preparation
- thermal conductivity

Programmable parameters (welding voltage, arc current, height of electrode, oscillation, torch travel speed, wire feed rate, etc.) in different specific cases

Expected result:
1. Outline matters which influence to propel weld in mechanized welding.
2. Outline parameters in mechanized welding compared to manual welding.

MM 3.5 Quality assurance in mechanized welding, NDT of welds (2 hrs)

Objective:
The student will be acquainted with general matters that influence welding and also will be acquainted with the main NDT methods used in quality assurance.

Scope:
General NDT technology
Visual examination
X-ray examination
Ultrasonic testing

Expected result:
1. Outline different NDT technologies.
2. Outline visual examination.

MM 3.6 Health and safety consideration in mechanized welding (2 hr)

Objective:
The student will understand the main hazards in arc welding and especially in mechanized welding

Scope:
Introduction to health and safety requirements
Hazards of electric power
Electro-magnetic fields
Connecting of equipment
Problems with shielding gases
Radiation and eye protection
Welding fume emission
Noise levels and ear protection
Special risks for automated processes
Hazards regarding the heat
Protective clothing

Expected result:
1. Detail the risks and hazards associated with mechanized welding from electricity, gases, fumes, fire, radiation and noise.
2. Interpret correctly the health and safety regulations with respect to the above hazards.

3.4 Module 3O: Orbital welding systems and programming 8h

MO 3.1 Structure of orbital welding systems (1 hr)

Objective:
The student will be acquainted with good knowledge of orbital welding systems.

Scope:
Components of orbital welding system:
- welding head
- welding power source
- internal or external steering computer, cables, cooling- and gas-systems

Semi-automatic welding systems

Expected result:
1. Outline the main components in typical orbital welding systems.

MO 3.2 Arc welding processes for orbital welding, TIG cold and hot wire welding and other possible processes (MIG/MAG/FCAW) (1 hr)

Objective:
The student will be acquainted with the processes used in orbital welding, TIG and MIG/MAG welding and hot/cold wire feeding.

Scope:
Welding processes for mechanized welding:
- TIG
- TIG, hot and cold wire feeding
- other processes

Expected result:
1. Outline TIG welding as main process in orbital welding
2. Outline processes to increase productivity by extra wire feeding.

MO 3.3 Joint preparation in orbital welding (1 hr)

Objective:
The student will be acquainted with different joint preparation techniques and the importance of accuracy for orbital welding quality.

Scope:
Accuracy of joint preparation
Joint preparation systems:
- mechanical saw
- mechanical lathe
- inside fixed machines (distending mandrel, jaws)
- bevelling machines

Expected result:
3. Outline main joint preparation systems.
4. Outline joint preparation accuracy.

MO 3.4 Material technology and welding metallurgy in orbital welding (1 hr)

Objective:
The student will be acquainted with tube materials and metallurgical matters in orbital welding.

Scope:
Tubes and tube standards and tolerances
Different types of metals can be welded
- high-strength, high-temperature and corrosion-resistant steels
- unalloyed and low-alloyed carbon steels
- nickel alloys
- titanium
- copper
- aluminium and associated alloys

Control of heat input in welding

Expected result:
1. Outline tubes and tube standards in orbital welding.
2. Outline different metals can be welded in orbital welding

MO 3.5 Setting up, welding parameters and programming of orbital welding systems (2 hrs)

Objective:
The student will be acquainted with programmable parameters and other factors that influence weld quality.

Scope:
Setting up different welding systems before welding
The aspects to be taken into account:

- arc length
- magnitude and pulse frequency of the welding current
- welding speed
- inert shielding gas
- parent material
- filler material
- weld preparation
- thermal conductivity

Programmable parameters (welding voltage, arc current, height of electrode, oscillation, torch travel speed, wire feed rate, hot wire current)

Expected result:
1. Outline the factors that influence weld quality.
2. Outline parameters in orbital welding and outline how those influence to proper weld.

MO 3.6 Quality assurance in orbital welding, NDT of welds (1 hr)

Objective:
The student will be acquainted with general matters that influence welding and also will be acquainted with the main NDT methods used in quality assurance.

Scope:
General NDT technology
Visual examination
X-ray examination
Ultrasonic testing

Expected result:
1. Outline different NDT technologies.
2. Outline visual examination in practise.

MO 3.7 Health and safety consideration in orbital welding (1 hr)

Objective:
The student will understand the main hazards in arc welding and especially in orbital welding

Scope:
Introduction to health and safety requirements
Hazards of electric power
Electro-magnetic fields
Connecting of equipment
Problems with shielding gases
Radiation and eye protection
Welding fume emission

Noise levels and ear protection
Special risks for automated processes
Hazards regarding the heat
Protective clothing

Expected result:

1. Explain the risks and hazards associated with orbital welding from electricity, gases, fumes, fire, radiation and noise.
2. Interpret correctly the Health and Safety regulations with respect to the above hazards.

3.5 Module 3R: Robot welding systems and programming 24h

MR 3.1 Basics of robotics and robot welding systems

MR 3.1.1 Basics of robotics (basics of joint axes robots for welding) (2 hrs)

Objective:
The student will be introduced to different industrial robot types and their usage in industrial applications. To illustrate the need for different types of robots, examples of robots will be given.

Scope:
Different industrial robot types
Industrial robot kinematic types
Examples of different robots and their application fields

Expected result:

1. Outline the need for different robot types.
2. Outline the key features of a welding robot.
3. Get picture of where robots can be utilized in industry.

MR 3.1.2 Robot systems (2 hrs)

Objective:
The student will understand the main components of a robot system. Control and communication inside and outside the robot system will be introduced. Industrial examples of robot systems of different types will be given.

Scope:
Teach pendant
Auxiliary axis
Positioners
Material feeding
Sensors
I/O signals
Communication
Control systems
Collision detection systems

Expected result:

1. Explain the main components in a robot system.
2. Outline the control possibilities inside a robot system.

3. Introduce basic principles in robot layout design.

MR 3.1.3 Structures of robot welding systems (2 hrs)

Objective:
The student will understand the structures of different robot welding systems and advantages and disadvantages in different applications. Student will also understand components of welding robot systems.

Scope:
Welding equipment
Welding power course
Wire feed systems
Welding consumables
Torch cleaning systems
Material handling tables
External axels
Redundancy in robot welding
Flexible Manufacturing Systems – FMS, Flexible Manufacturing Unit – FMU, Computer Integrated Manufacturing – CIM and Flexible Manufacturing Factory – FMF

Expected result:
1. Explain components of robot welding unit.
2. Outline the advantages and disadvantages of differing robots in different applications.
3. Outline FM systems.

MR 3.1.4 Health and safety considerations in robot systems (2 hrs)

Objective:
The student will understand the main safety hazards in a typical robot work cell. Safe working procedures in robot programming will be introduced. Brief introduction to key points of EN 10218-1 'Robots for industrial environments – Safety requirements'

Scope:
Hazards caused by robots
Robot safety principles according to EN 10218-1
Safe operation principles

Expected result:
1. Explain the potential hazard in a typical robot work cell.
2. Outline a safe system of operation for welding robots.

MR 3.2 Robot programming in welding and efficient use

MR 3.2.1 Arc welding processes for robot welding (MIG/MAG, TIG, PAW) (2 hrs)

Objective:
The student will achieve basic knowledge about the most common welding processes to robotize.

Scope:
Description of the most common processes that can be applied to robot applications within the robot welding field.
- MIG, MAG
- TIG

- PAW

Expected result:

1. Identify welding methods and their merits for a given work piece.
2. Outline possibilities to increase productivity in robot welding.

MR 3.2.2 Other welding processes for robot welding (resistance, laser, hybrid welding) (2 hrs)

Objective:

The student will achieve basic knowledge about other welding processes to robotize.

Scope:

Description of other welding processes that can be applied to robot applications within the robot welding field.

- resistance welding
- laser welding, hybrid welding
- allied processes

Expected result:

1. Identify alternative welding methods and their merits for a given work piece.
2. Outline benefits to robotize welding processes.

MR 3.2.3 Programming of robot (2 hrs)

Objective:

The student will understand the main programming methods for industrial robots in different applications. Main aspects of different programming methods will be described. Basic of programming methodology will be introduced.

Scope:

On-line programming

- Teach pendant programming language
- Coordinating systems
- Robot motion types, robot program creation

Teach pendant menus and displays and programming commands and weld data
Basics of off-line programming
Structure and syntax of a robot program

Expected result:

1. Explain difference between robot programming methods.
2. Basic knowledge to evaluate when on-line programming is adequate and when to select off-line programming.

MR 3.2.4 Programming of welding robot (2 hrs)

Objective:

The student will understand main programming features when programming a welding robot.

Scope:

Entering welding routines
Arc sensing
Robot welding fundamentals
Proper orientation of parts for programming and welding
Torch and wrist alignment procedures

Robot and system error recovery

Expected result:
1. Explain programming routines when programming welding robot.

MR 3.2.5 Seam tracking systems and sensors in robot welding (2 hrs)

Objective:
The student will understand the meaning of seam tracking and different kind of methods of seam tracking.

Scope:
Definitions of different seam tracking technologies
Special seam tracking sensors the robot in welding applications
Vision systems in quality control and inspection
Force/torque sensors mounted to a robot's wrist
Additional sensory devices to improve robustness, flexibility and performance of robot applications

Expected result:
1. Explain seam tracking systems.
2. Outline additional sensors in robot welding.

MR 3.2.6 Multi robot welding systems (1 hr)

Objective:
The student will be acquainted with general matters that influence multi robot welding and also will be acquainted with different kinds of multi robot systems.

Scope:
Requirements for multi robot welding in welding fabrication
Examples of multi robot welding systems:
- master/slave robot systems
- programming of multi robot systems
- agile robotics in welding with manual welding
- mobile welding robots
- Flexible Manufacturing Systems – FMS, Flexible Manufacturing Unit – FMU, Computer Integrated Manufacturing – CIM and Flexible Manufacturing Factory – FMF
  Latest innovations in robot welding systems

Expected result:
1. Outline the general matters that influence multi robot welding.
2. Outline the structure and programming of systems.
3. Outline the latest development trends in multi robot welding technology.

MR 3.2.7 Offline programming and graphic simulation in robot welding (2 hrs)

Objective:
The student will be introduced to basic techniques and methods used in off-line programming (OLP) of welding robots. Requirements and advantages of OLP will be presented. Different OLP and simulation solutions and software will be introduced.

Scope:
OLP basic
OLP requirements
Available OLP solutions
Work cell simulation
Calibration of simulation model, downloading and testing of robot program

Expected result:
1. Explain the basic principles and methods of welding robot off-line programming.
2. Outline the basic requirements to the manufacturing process.
3. Outline the main differences between on-line programming and OLP.
4. Outline procedure steps from offline programming to robot welding.

MR 3.3 Joint preparation for robot welding (2 hrs)

Objective:
The student will be acquainted with different joint and edge preparation techniques and the importance of accuracy for robot welding quality.

Scope:
Survey of edge preparation processes
Accuracy and tolerances of joint preparation
Mechanical joint preparation systems:
- mechanical saw
- mechanical lathe
- bevelling machines

Principles of flame and flame powder cutting
Fundamentals of plasma cutting
Fundamentals of laser cutting

Expected result:
5. Outline main joint preparation systems.
6. Outline joint preparation accuracy.

MR 3.4 Maintenance (2 hr)

Objective:
Student will be familiar with maintenance planning, daily routines in maintenance and the meaning of risk analysis.

Scope:
Basic task in process maintenance
Daily maintenance routines such as:
- control of TCP (Tool Center Point)
- cleaning of robot station, positioners and fixtures
- emergency stops
- program library
- gas and water controls

- control wire feed units, contact tips, liners, etc.
- trouble shooting

Risk analysis

Expected result:

1. Outline the importance and purpose of maintenance.
2. Explain fully daily maintenance routines.

3.6 Module 4: Design and economy of mechanized, orbital and robot welding systems 16h

(for Comprehensive level only)

M 4.1 Optimizing of intelligence levels in welding (3 hrs)

Objective:

The student will understand which factors influence optimisation of intelligence levels in welding fabrication.

Scope:

Intelligence in different welding systems
Intelligence classification in welding
Selecting of intelligence level

Expected result:

1. Outline intelligence in different welding systems.
2. Describe intelligence classification in welding.
3. Select the intelligence level in appropriate situation.

M 4.2 Investment planning of automated and robot welding systems (3 hrs)

Objective:

The student will understand how to analyse welding production for automation and robot welding. Also students will become familiar with investment factors and possibilities in modern fabrication.

Scope:

Preliminary planning (product analysis, weld analysis, production analysis, jig analysis)
Productivity and turnaround time, influence to other production processes
Manned/unmanned production, multi-robot systems/single robot systems
Environmental matters
Budgeting, comparison of different systems
Cost of investment, implementation and usage
Timetable of implementation

Expected result:

1. Explain details of different analyses
2. Outline investment planning details
3. Outline details and factors which influence to selection of system

M 4.3 Design of robot welding systems (3 hrs)

Objective:

The student will achieve a good knowledge of weld design for use by robot welding systems.

Scope:
The potential possibilities of the design department to influence the level of robotization. Consideration to be given:

- accessibility
- fillet weld/butt weld
- joint configuration
- welding position
- optimization of the process; penetration and throat thickness/leg length
- fixture design

Expected result:

1. Explain welded product design requirements to optimise suitability for robotization of the welded production.

M 4.4 Lay-out in workshop (2 hrs)

Objective:
The student will achieve a basic knowledge of welding workshop design and lay-out using modern design tools e.g. computer aided virtual factory systems.

Scope:
Installation of a robot system in

- production
- physical work environment
- co-operation within the organisation of company

Computer aided virtual factory systems, available programs

Expected result:

1. Identify suitable layout of robot systems.
2. Capable to make physical risk analysis.
3. Outline computer aided virtual factory systems

M 4.5 Efficient implementation of robot welding systems (3 hrs)

Objective:
The student will understand how to implement robot welding systems to improve production efficiency.

Scope:
Selection of robot system(s)

- results of weld analysis
- selection of welding parameters, sensors and material handling equipments
- working area of robot, concept of robot unit

Welding parameters in selected welding process, WPS
Operator/personnel training and qualification
Selection of programming methods
Design of jigs and fixtures
Sensors and quality assurance
Automatization of material handling
Rationalization possibilities of production and welding fabrication

Expected result:

1. Explain the factors that influence efficient implementation of robot welding systems
2. Outline possibilities to increase production efficiency

M 4.6 Economy and productivity in robot welding systems (2 hrs)

Objective:

To achieve knowledge of the welding cost parameters, their importance to and influence over economy and productivity for different robot welding applications.

Scope:

Good ability to calculate welding production costs for manual and flexible mechanized welding systems for various batch sizes.
Identify for robot welding applications the importance of the following factors:

- capital costs
- labour
- utilization factors
- maintenance
- consumables
- shielding gas
- supplies such as electric power, water, compressed air, etc.
- operator training costs

Expected result:

1. Calculate the welding costs for various mechanized production situations in comparison with manual welding.
2. Explain different factors which have influence to economy and productivity to robot welding applications.

3.7 Module 5: Design of welded structures for mechanized, orbital and robot welding systems 24h

(for Comprehensive level only)

M 5.1 Design of welded structures for mechanized and orbital welding (4 hrs)

Objective:
The student will understand the meaning of light mechanization and how to design for it. The student will also get a good understanding of best practises for cost-effective design for mechanization.

Scope:
Meaning of light mechanization
Structures for light mechanization
Cost effective design for mechanization.

Expected result:
1. Explain how to optimise cost-efficient design for mechanization.

M 5.2 Design of welded structures for mechanized and robot welding (8 hrs)

Objective:
The student will understand theoretical and practical limitations, requirements and benefits of design of welded structures for robot welding. The student will understand the most essential requirements and available benefits involved in use of robotic welding (compared to conventional welding) and to design the constructions suitable for effective robotic welding.

Scope:
Constructional requirements must be fulfilled for utilizing of robot welding
Different processes purposeful for certain design applications
Constructional advantages and performances for fabrication by using robotic welding
Constructional requirements what to take into account when choosing constructional lay-out and on detail design
Design influence and choice to constructional behavior and costs (fabrication and other costs)

Expected result:
1. Explain the constructional requirements necessary for the application of robot welding.
2. Explain the different design processes that are applicable to certain design applications.
3. Describe the constructional advantages and performances for fabrication that can be achieved using robotic welding.
4. Detail the requirements that must be taken into account when choosing constructional lay-out and on detail design.
5. Explain the effects that those choices will have on constructional behavior and costs (fabrication and other costs).

M 5.3 Preparation for mechanized and orbital welding (2 hrs)

Objective:
The student will understand basic principles and of the most common cutting and edge preparation processes used in mechanized and orbital welding.

Scope:
Types of joints for orbital welding
Types of joints for mechanized welding
Removal the impurities
Edge preparation processes
Welding jigs and fixtures

Expected result:
1. Identify principles of selection of joint types in orbital welding.
2. Identify principles of selection of joint types in mechanized welding.
3. Identify principles of edge preparation processes.

M 5.4 Preparation for robot welding (3 hrs)

Objective:
The student will understand basic principles and of the most common cutting and edge preparation processes used in robot welding.

Scope*:*
Types of joints for robot welding
Removal the impurities
Edge preparation processes
Welding jigs and fixtures

Expected result:
1. Identify principles of selection of joint types for robot welding.
2. Identify principles of edge preparation processes.
3. Identify suitable welding jigs and fixtures

M 5.5 Design in robot welding jigs and fixtures (4 hrs)

Objective:
The student will understand process sequence to design jigs and fixtures and also different possibilities to make those systems efficient to use.

Scope:
Main body
How find best solution to design jigs and fixtures
Sublementary elements and fixing elements
Other attaching means
Clamping apparatus
Meaning of design without jigs and fixtures

Expected result:

1. Explain how to design jigs and fixtures for robot welding.
2. Outline the sequence for design.
3. Outline design without jigs and fixtures

M 5.6 Best practises of design of welded structures for robot welding (3 hrs)

Objective:

The student will understand good solution of design of welded structures for robot welding by industrial best practise cases.

Scope:

Best solution of design of welded structures for robot welding by industrial best practise cases

Expected result:

1. Explain the industry best practice approach to design of welded structures for robot welding.

3.8 Module 6: Case Studies — 16h

(for Comprehensive level only)

M 6.1 Best practises in welding fabrication and automation (4 hrs)

Objective:
The student will understand how to avoid problems when starting welding automation and robotization.

Scope:
Co-operation between design and fabrication
How to avoid problems with other production
Possible problems if wrong designed welding system/unit
Differences in welding equipment in manual welding compared to robot welding
Welding consumables and shielding gas systems for robot welding
Tolerances in subparts, preparation and materials of welded parts
Training of personnel in preparation, online/offline programming and welding
Daily maintenance of robot and control of components (contact tips, gas diffusers, gas nozzles and various liners, etc.)
Maintenance of jigs and fixtures

Expected result:
1. Outline how to avoid problems when starting welding automation and robotization.

M 6.2 Practical cases from industry

M 6.2.1 Practical cases from industry in mechanized welding (3 hrs)

Objective:
The student will understand practical methods to solve problems in welding mechanization through the analysis of welding industry case studies.

Scope:
Mechanized welding cases from welding industry

Expected result:
1. Explain the best solutions and tips for solving problems in mechanized welding using cases from the welding industry.

M 6.2.2 Practical cases from industry in orbital welding (1 hr)

Objective:
The student will understand practical methods to solve problems in orbital welding through the analysis of welding industry case studies.

Scope:
Orbital welding cases from welding industry

Expected result:
1. Explain the best solutions and tips for solving problems in orbital welding using cases from the welding industry.

M 6.2.3 Practical cases from industry in robot welding (8 hrs)

Objective:
The student will understand practical methods for solving problems in robot welding through the analysis of welding industry case studies.

Scope:
Robot welding cases from welding industry

Expected result:
1. Explain the best solutions and tips for solving problems in robot welding using cases from the welding industry

3.9 Module 7M: Practical education in mechanized welding 4h

(for Comprehensive level only)

MM 7.1 Welding demonstrations mechanized welding (2 hrs)

Objective:
The student will understand different kinds of mechanized welding systems in real action and will also understand how to control operations and parameters. Demonstration should be in a real environment but to get larger image of different systems, also videos etc. can be used.

Scope:
Operations and control before welding
Operations and control during welding
Operations and control after welding

Expected result:
1. Outline operations and control before welding.
2. Outline operations and control during welding.
3. Outline operations and control after welding.

MM 7.2 Parameters in mechanized welding (1 hr)

Objective:
The student will understand how to control different parameters during welding and how those influence to weld quality

Scope:
Main parameters to be controlled in during welding; current, voltage, travel speed, wire feeding…

Expected result:
1. Outline operations and control of parameters during welding.

MM 7.3 Visual examination of welded structures in mechanized welding (1 hr)

Objective:
The student will understand how to do visual testing after welding.

Scope:
Visual examination
Visual examination documentation

Expected result:
1. Explain visual examination after welding.

Module 7M: Practical education in mechanized welding **32h**
(for Basic level only)

MM 7.4 Functional knowledge appropriate to the mechanized welding unit (2 hrs)

Objective:
The student will understand the functional knowledge requirements, appropriate to the welding unit, for a welding operator/weld setter to ensure that procedures are followed and common practices are complied with.

Scope:
Welding sequences/procedures in the relevant process
Joint preparation and weld representation in the relevant process
Weld imperfection in the relevant process
Welding operator's/weld setter's qualification
Process operation

Expected result:
1. Understand welding sequences/procedures in the relevant process
2. Understand joint preparation and weld representation in the relevant process
3. Understand weld imperfection in the relevant process
4. Understand welding operator's/weld setter's qualification
5. Understand process operations

MM 7.5 Knowledge on welding technology (2 hrs)

Objective:
The student will understand what job knowledge a welding operator/weld setter should have to ensure that procedures are followed and common practices are complied with.

Scope:
Welding equipment
Parent metals
Consumables
Safety and accident prevention
Visual examination of welds

Expected result:
1. Outline welding equipment in the relevant process
2. Outline parent material and consumables in the relevant process
3. Outline safety and accident prevention in the relevant process
4. Outline visual examination of welds

MM 7.6 Programming exercises in mechanized welding (8 hrs)

Objective:
To achieve knowledge in practical setting up and programming in appropriate mechanized welding system(s).

Scope:
Setting up the system(s)
Programming of system(s)
Use of WPS

Expected result:
1. Explain how to set up and program in appropriate mechanized welding system(s).

MM 7.7 Mechanized welding exercises (16 hrs)

Objective:
To achieve knowledge in practical use of appropriate mechanized welding system(s).

Scope:
Welding parameters, control of weld quality
Visual examination of welds

Expected result:
1. Explain how to appropriate mechanized welding system(s) works to proper weld and what are operator's duties during welding.

MM 7.8 Qualification tests of the operator (2 hrs)

3.10 Module 7O: Practical education in orbital welding **4h**
(for Comprehensive level)

MO 7.1 Welding demonstrations orbital welding (2 hrs)

Objective:
The student will understand different kinds of orbital welding system in real action and will also understand how to control operations and parameters. Demonstration should be in a real environment but to get larger image of different systems, also videos etc. can be used.

Scope:
Operations and control before welding
Operations and control during welding
Operations and control after welding

Expected result:
1. Outline operations and control before welding.
2. Outline operations and control during welding.
3. Outline operations and control after welding.

MO 7.2 Parameters in orbital welding (1 hr)

Objective:
The student will understand how to control different parameters during welding and how they influence weld quality.

Scope:
Main parameters to be controlled in during welding; current, voltage, travel speed, wire feeding, etc.

Expected result:
1. Outline operations and control of parameters during welding.

MO 7.3 Visual examination of welded structures in orbital welding (1 hr)

Objective:
The student will understand how to do visual testing after welding.

Scope:
Visual examination
Visual examination documentation

Expected result:
1. Explain visual examination after welding for Basic level

Module 7O: Practical education in orbital welding **32h**
(for Basic level only)

MO 7.4 Functional knowledge appropriate to the orbital welding unit (2 hrs)

Objective:
The student will understand the functional knowledge requirements, appropriate to the welding unit, for a welding operator/weld setter to ensure that procedures are followed and common practices are complied with.

Scope:
Welding sequences/procedures in the relevant process
Joint preparation and weld representation in the relevant process
Weld imperfection in the relevant process
Welding operator's/weld setter's qualification
Process operation

Expected result:
1. Outline welding sequences/procedures in the relevant process.
2. Outline joint preparation and weld representation in the relevant process.
3. Outline weld imperfection in the relevant process.
4. Outline welding operator's/weld setter's qualification.
5. Outline process operations.

MO 7.5 Knowledge on welding technology (2 hrs)

Objective:
The student will understand the job knowledge required by a welding operator/weld setter to ensure that procedures are followed and common practices are complied with.

Scope:
Welding equipment
Parent metals
Consumables
Safety and accident prevention
Visual examination of welds

Expected result:
1. Outline welding equipment in the relevant process
2. Outline parent material and consumables in the relevant process
3. Outline safety and accident prevention in the relevant process
4. Outline visual examination of welds

MO 7.6 Programming exercises in orbital welding (8 hrs)

Objective:
To achieve knowledge in practical setting up and programming in appropriate orbital welding system(s).

Scope:
Setting up the system(s)
Programming of system(s)
Use of WPS

Expected result:
1. Explain how to set up and program in appropriate orbital welding system(s).

MO 7.7 Orbital welding exercises (16 hrs)

Objective:
To achieve knowledge in practical use of appropriate orbital welding system(s)

Scope:
Welding parameters, control of weld quality
Visual examination of welds

Expected result:
1. Explain how to appropriate orbital welding system(s) works to proper weld and what are operator's duties during welding.

MO 7.8 Qualification tests of the operator (2 hrs)

3.11 Module 7R: Practical education in robot welding — 32h

(for Comprehensive level only)

MR 7.1 Programming exercises of the robots (8 hrs)

Objective:
The student will understand how to perform online programming of robots (at least should be 2 – 3 different kind of robot supplier's robot mark in training facility or local industry).

Scope:
Basic outline of programming
Coordinating systems
Robot motion types, robot program creation (point to point programming, circle programming, etc.)
Teach pendant programming (menus, displays, programming commands)
Structure and syntax of a robot program
Communication with other systems (FMS)
Robot and system error recovery

Expected result:
1. Explain robot programming in practice.
2. Explain programming types and program structure
3. Outline communication with other systems

MR 7.2 Programming exercises of welding robot (8 hrs)

Objective:
The student will understand how to program a welding robot.

Scope:
Robot welding fundamentals
Joint finding, seam tracking and other sensors in welding
Setting of welding parameters according to WPS
Multilayer welding
Self adaptive systems
Communication with welding equipment and outer computer(s)
Robot and system error recovery in welding
Visual examination of welds
Minimum cycle time

Expected result:
1. Explain programming routines when programming welding robot in practise.

MR 7.3 Offline programming exercises (16 hrs)

Objective:
The student will understand the meaning of offline programming and how to model a robot unit and a whole system.

Scope:
OLP basics
Work sell modelling and simulation
Testing of different robot in same work sell
Calibration of work sell

Downloading and testing of robot program

Expected result:
1. Explain the main differences between on-line programming and OLP.
2. Explain procedure steps from offline programming to robot welding.

Module 7R: Practical education in robot welding **46h**
(for Basic level only)

MR 7.4 Functional knowledge appropriate to the robot welding unit (2 hrs)

Objective:
The student will understand the functional knowledge requirements, appropriate to the welding unit, for a welding operator/weld setter to ensure that procedures are followed and common practices are complied with.

Scope:
Welding sequences/procedures in the relevant process
Joint preparation and weld representation in the relevant process
Weld imperfection in the relevant process
Welding operator's/weld setter's qualification
Process operation

Expected result:
1. Outline welding sequences/procedures in the relevant process
2. Outline joint preparation and weld representation in the relevant process
3. Outline weld imperfection in the relevant process
4. Outline welding operator's/weld setter's qualification
5. Outline process operations

MR 7.5 Knowledge on welding technology (2 hrs)

Objective:
The student will understand the job knowledge required by a welding operator/weld setter to ensure that procedures are followed and common practices are complied with.

Scope:
Welding equipment
Parent metals
Consumables
Safety and accident prevention
Visual examination of welds

Expected result:
1. Outline welding equipment in the relevant process
2. Outline parent material and consumables in the relevant process
3. Outline safety and accident prevention in the relevant process
4. Outline visual examination of welds

MR 7.6 Programming exercises of the robot (8 hrs)

Objective:
The student will understand how online program a robot.

Scope:
Basic outline of programming
Coordinating systems
Robot motion types, robot program creation (point to point programming, circle programming, etc.)
Teach pendant programming (menus, displays, programming commands)
Structure and syntax of a robot program
Communication with other systems (FMS)
Robot and system error recovery

Expected result:
1. Explain robot programming in practice.
2. Explain programming types and program structure.
3. Outline communication with other systems.

MR 7.7 Programming exercises of welding robot (16 hrs)

Objective:
The student will understand how to program a welding robot and

Scope:
Robot welding fundamentals
Joint finding, seam tracking and other sensors in welding
Setting of welding parameters according to WPS
Multilayer welding
Self adaptive systems
Communication with welding equipments and outer computer(s)
Robot and system error recovery in welding
Visual examination of welds

Expected result:
1. Explain programming routines when programming a welding robot in practise.

MR 7.8 Offline programming exercises (16 hrs)

Objective:
The student will understand the meaning of offline programming and how to model a robot unit and a whole system.

Scope:
OLP basics
Work sell modelling and simulation
Testing of different robot in same work sell
Calibration of work sell
Downloading and testing of robot program

Expected result:
1. Outline the main differences between on-line programming and OLP.
2. Outline procedure steps from offline programming to robot welding.

MR 7.9 Qualification tests of the operator (2 hrs)

4. SECTION II - EXAMINATIONS

4.1 Introduction

This guideline seeks to achieve harmonization of examination and qualification of personnel involved mechanized, orbital and robot welding activities. The national welding organizations, being members of IIW, mutually acknowledge the Diplomas awarded in any member Country to mechanized, orbital and robot welding personnel following examination conducted in accordance with this guideline.

Education must follow this IIW guideline and the examination must be conducted by the Authorized National Body.

4.2 Examination procedures and administration

Procedures and administration are covered by Document IAB-001(see latest edition).

4.3 Approval of the training course

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

4.4 Examination Board

An examination Board, acting on behalf of the ANB supervises the examination therefore independence, integrity and fairness of the examination system are maintained.

4.5 Admission to the examination

Admission to the examination leading to the award of the mechanized, orbital and robot welding personnel diplomas will be restricted to those:

a) who comply with the minimum requirements specified in the directory of the access conditions, and
b) who have attended at least 90% of the course, approved by the ANB, according to this guideline.

Exceptions are at the ANB discretion only for the attendance requirement.

4.6 Examination procedures at Comprehensive level

The examination procedures described below are designed to test the candidate's knowledge and understanding of different situations in mechanized, orbital and robot welding activities in industry. There will be written examinations which have a series of multiple choice questions and essay questions in each of the following modules:

Module 1: Basics of mechanized, orbital and robot welding
Module 2: The quality assurance in mechanized, orbital and robot welding
Module 3: Different welding systems and programming
Module 4: Design and economy of mechanized, orbital and robot welding systems

Module 5: Design of welded structures for mechanized, orbital and robot welding
Module 6: Case studies

The examination shall include questions relevant to each module, but the examination may be separated into two parts, as follows:
- Exam 1: modules 1, 2 and 3;
- Exam 2 modules 4, 5 and 6.
The questions must to reflect the course topics.
The duration of the written examination shall be a minimum of 0,5 hours for each of modules 1 and 2, and 1 hour for each of modules 3, 4, 5 and 6. However, the total examination time for all six modules shall be a minimum of 5 hours.

Module 7 (Practical exercises) will not be covered by the examination for robot welding personnel at the Comprehensive level.

4.7 Examination procedures at Basic level

The examination procedures described below are designed to test the candidate's knowledge and understanding of different situations in mechanized, orbital and robot welding activities in industry. There will be a series of multiple choice questions covering the whole field of each following modules:

Module 1: Basics of mechanized, orbital and robot welding
Module 2: The quality assurance in mechanized, orbital and robot welding
Module 3: Different welding systems and programming

The questions are to reflect the course topics. The duration of the multiple choice questions shall be a minimum of 0,5 hours per module. However, the total examination time for all three modules shall be a minimum of 1,5 hours.

The practical examination shall fulfil the ISO 14732 requirements, any practical exam is accepted but must be under the scope of the diploma.

4.8 Evaluation of performance

In order to pass the examination the candidates shall achieve at least 60 % of the maximum possible mark in each examination.

The examination for all applicable modules shall be completed within a period of 3 years from the date of the first examination.

4.9 Re-examination and appeals procedure

Failure in any individual module of the examination shall require re-examination only in the module failed. Re-examination may be retaken between 2 weeks and 15 months of the initial examination and, in the case of a second failure, one further attempt is permitted between 1 and 15 months from the date of the second examination. Failure at this third attempt will result in the candidate being treated as an initial candidate and a retake of the whole course will be required.
Candidates who feel they have been unfairly treated during the examination procedure have the right to appeal to the Authorized National Body.

4.10 International mechanized, orbital and robot welding diplomas

After successful examination the applicable diplomas are awarded to the candidate by the Authorized National Body.

Table 2 reports the full list of acronyms which shall be used in the diplomas and, as further reference, the relevant education modules.

ACRONYM	QUALIFICATION	MODULES
IMW–B	**International Diploma in Mechanized Welding at the Basic Level**	MODULE 1: basics of mechanized, orbital and robot welding MODULE 2: the quality assurance in mechanized, orbital and robot welding MODULE 3M: mechanized welding systems and programming MODULE 7M: practical education in mechanized welding
IOW–B	**International Diploma in Orbital Welding at the Basic Level**	MODULE 1: basics of mechanized, orbital and robot welding MODULE 2: the quality assurance in mechanized, orbital and robot welding MODULE 3O: orbital welding systems and programming MODULE 7O: practical education in orbital welding
IRW–B	**International Diploma in Robot Welding at the Basic Level**	MODULE 1: basics of mechanized, orbital and robot welding MODULE 2: the quality assurance in mechanized, orbital and robot welding MODULE 3R: robot welding systems and programming MODULE 7R: practical education in robot welding
IRW–C	**International Diploma in Robot Welding at the Comprehensive Level**	MODULE 1: basics of mechanized, orbital and robot welding MODULE 2: the quality assurance in mechanized, orbital and robot welding MODULE 3R: robot welding systems and programming MODULE 4: design and economy of mechanized, orbital and robot welding systems MODULE 5: design of welded structures for mechanized, orbital and robot welding MODULE 6: case studies MODULE 7R: practical education in robot welding
IMORW–C	**International Diploma in Mechanized, Orbital and Robot Welding at the Comprehensive Level**	MODULE 1: basics of mechanized, orbital and robot welding MODULE 2: the quality assurance in mechanized, orbital and robot welding MODULE 3M: mechanized welding systems and programming MODULE 3O: orbital welding systems and programming MODULE 3R: robot welding systems and programming MODULE 4: design and economy of mechanized, orbital and robot welding systems MODULE 5: design of welded structures for mechanized, orbital and robot welding MODULE 6: case studies MODULE 7M: practical education in mechanized welding MODULE 7O: practical education in orbital welding MODULE 7R: practical education in robot welding

Table 2 - Acronyms for the IIW qualifications for International Mechanized, Orbital and Robot Welding Personnel

4.11 Transitional arrangements

Transitional arrangements can be offered by the ANB for a period of up to 3,5 years from the date of approval of this guideline by the IIW Group A. Transitional award may be made to those already awarded of the EWF record of achievement for the Special Course in Robot Welding (Engineer, Technologist and Specialist levels) - doc. EWF-530-01 according to the following criteria:

- Engineer and Technologist level: IRW-C

In addition, each ANB can offer transitional arrangements for a period of up to 3,5 years from the date of addition of this guideline to the scope of the ANB through approval by the IAB Group A/B for national qualifications awarded through courses and examinations covering the specific (mechanized, orbital or robot welding) or the whole technology at the appropriate level (basic, standard), provided that:

- the access conditions to the relevant level are satisfied and
- the arrangements are approved by the IAB Group A/B.

APPENDIX 1:

Diagrams in International Mechanized, Orbital and Robot Welding at Basic and Comprehensive Levels education

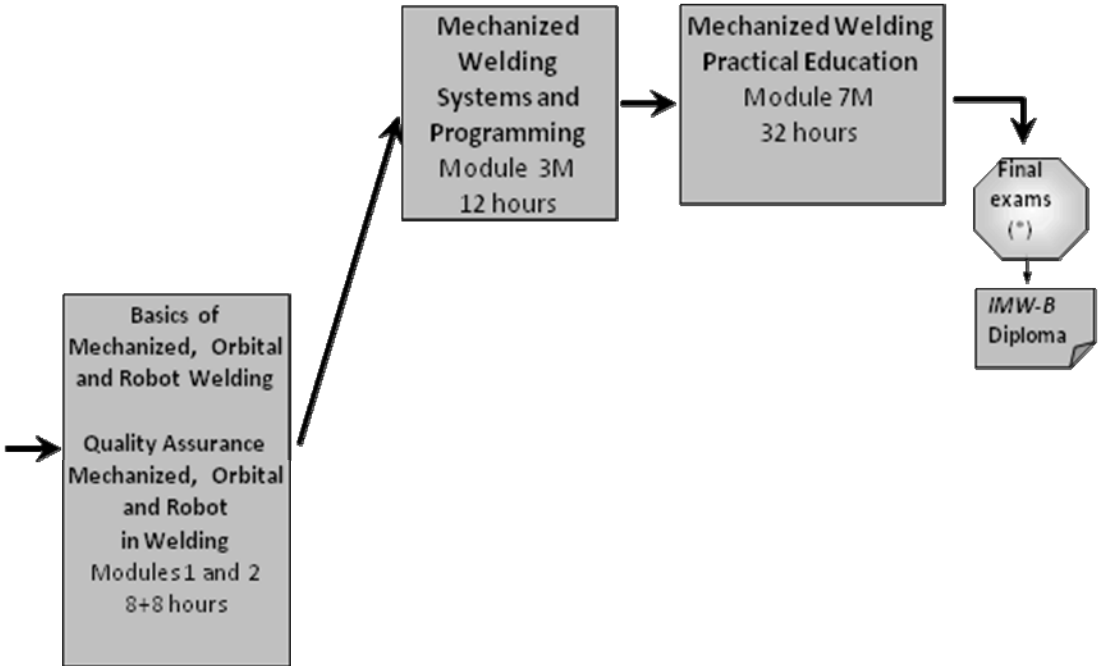


Diagram 2 - Training modules and hours in International Mechanized Welding at Basic level education.

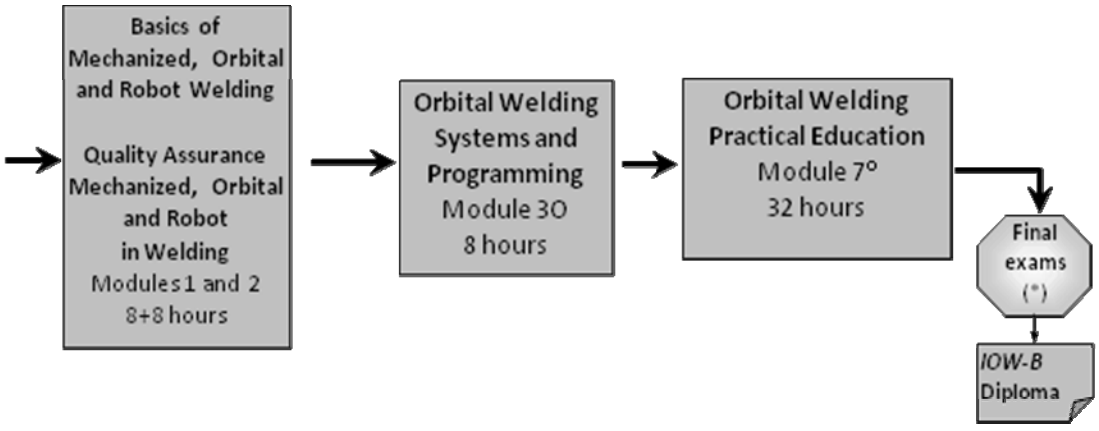


Diagram 3 - Training modules and hours in International Orbital Welding at Basic level education

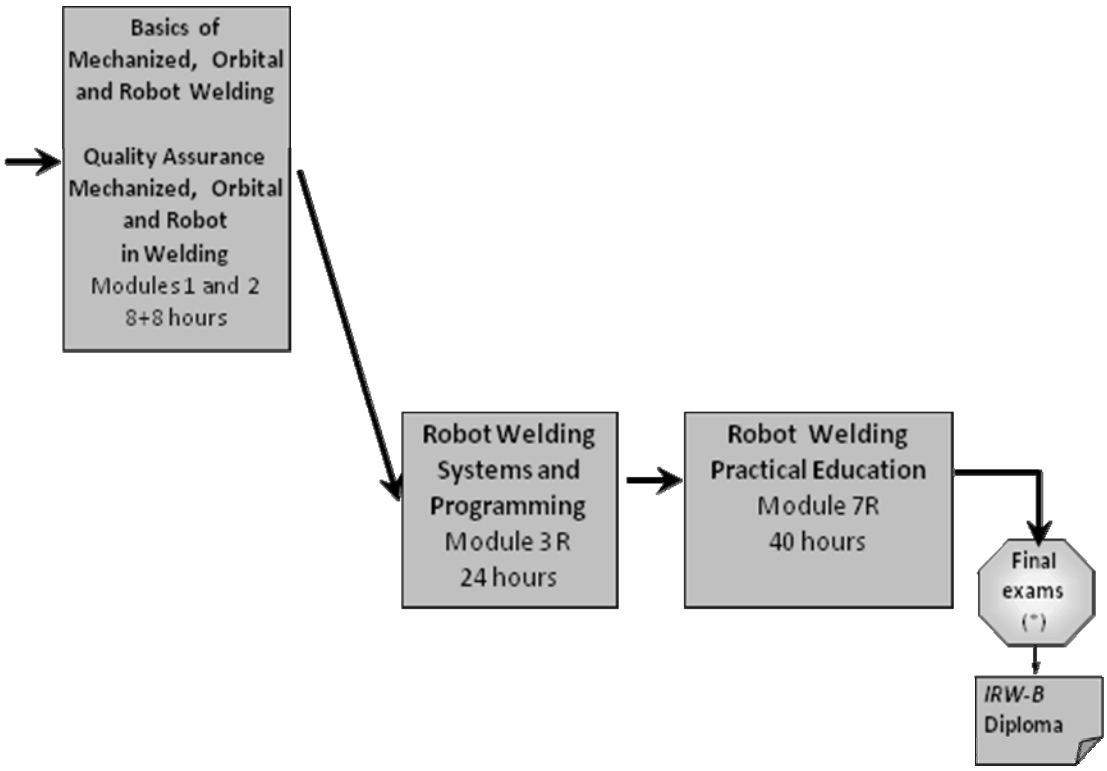


Diagram 4 - Training modules and hours in International Robot Welding at Basic level education.

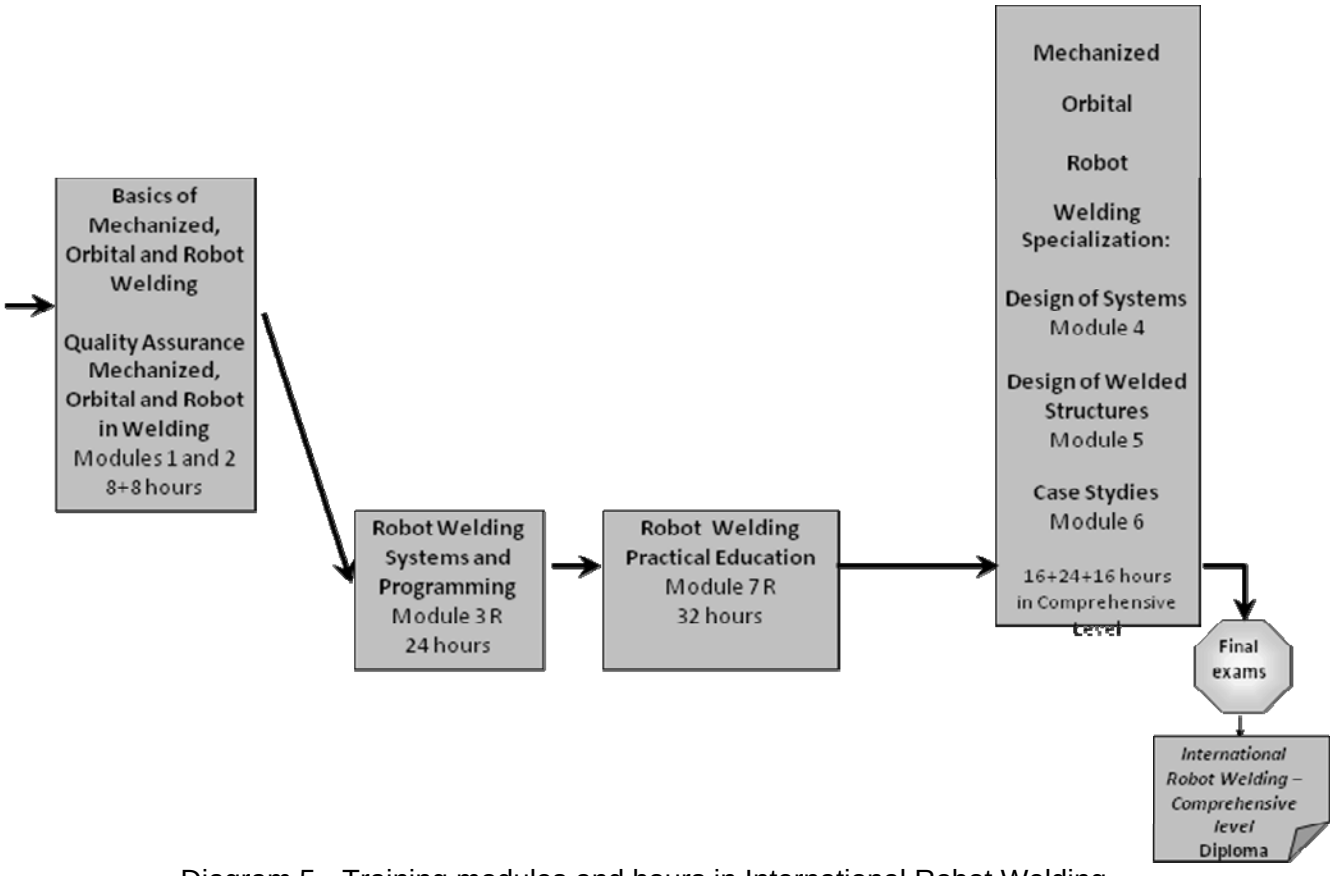


Diagram 5. -Training modules and hours in International Robot Welding at Comprehensive level education.

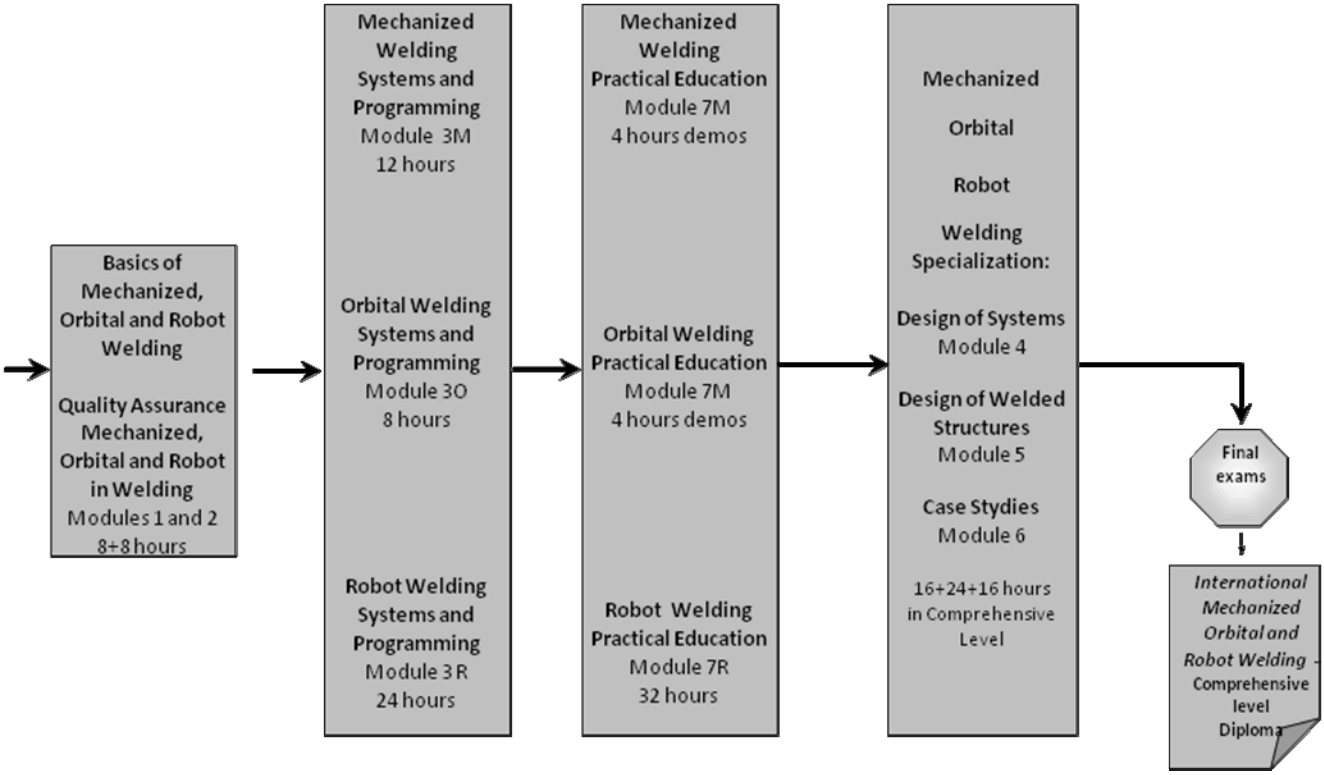


Diagram 6 - Training modules and hours in International Mechanized, Orbital and Robot Welding at Comprehensive level education.

APPENDIX 2:

Equipment requirements for practical education

1. General comment:

The ANB which is interested in mechanized, orbital and robot welding personnel training is recommended to apply full authorization of education mechanized, orbital and robot welding personnel training and qualification; this can also refer only to a single field of qualification (mechanized, orbital or robot welding).
Each ATB which will train mechanized, orbital and/or robot welding personnel will apply the authorization to route(s) and level(s) which is suitable for their market and local/national industry.

2. General requirements

It is allowed to carry on the laboratory work in close cooperation with local/national industry (e.g training at the customer's facilities). At least there should be available 2 – 3 different robot supplier's robot mark for better comparing of programming/testing of different systems.

All the equipment shall be in good working order and fit for its purpose.

3. Equipment requirements for practical education:

Equipment in practical education should fulfill requirements of selected route(s) and purposes of the qualification; this will include the following:

- mechanical testing, metallurgical examination and NDT equipment shall be available for both demonstration and laboratory work purposes.
- well documented specimens, polished and etched, reflecting the field of education and qualification.