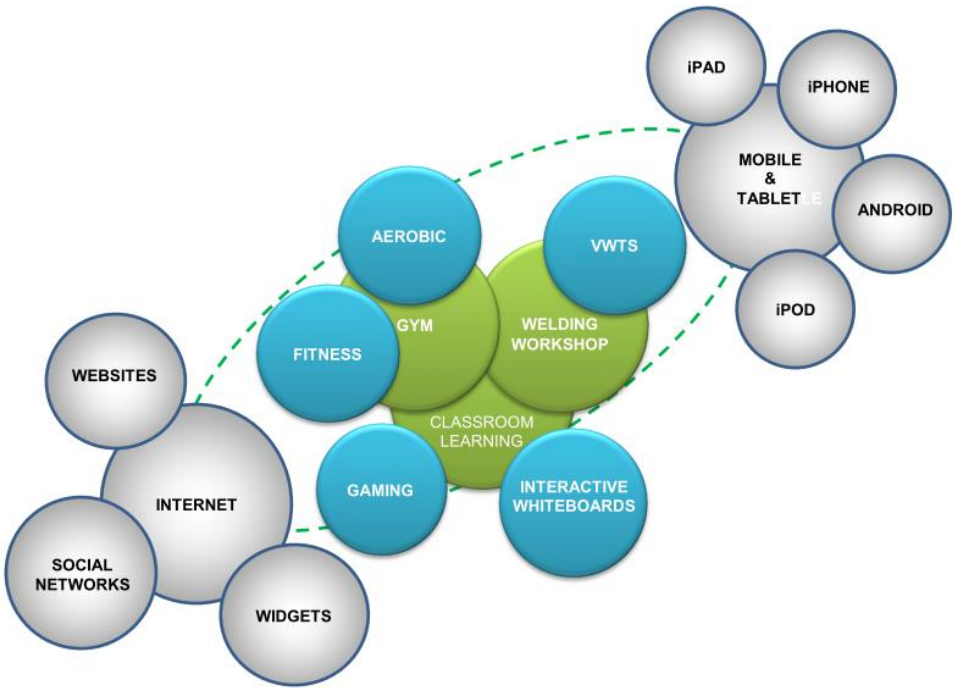
InteractivWeld
Leonardo da Vinci Partnership
2013-1-HR1-LEO04-03224

Lifelong Learning Programme

No.8

Guidebook



Integrated interactive system for lifelong education of welders

Slavonski Brod – Porto Salvo – Oberhausen – Basel – Wels - Zagreb

Contents

Introduction 2

Why is lifelong education of welders so important? 3
Approach to lifelong education of welders 3
Problem scale - conclusions 4
Who needs to get involved in finding the solution to the problem? 4

S-K-S system 5

Skills 5
In general 5
Skills for trainees 7
Skills for professionals 10

Knowledge 12
In general 12
Knowledge for trainees 13
Knowledge for professionals 15

Stability 16
In general 16
Stability for trainees 17
Stability for professionals 18

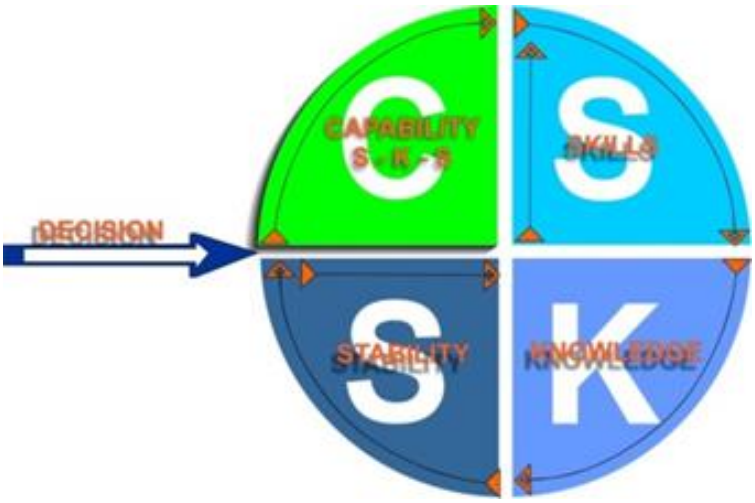
Recommendations 20

In general 20
Recommendations for the implementation of S-K-S System for the Welder education within the EWF Qualification System 21

Introduction:

The S-K-S system is integrated interactive system for lifelong education of welders.
The system directed towards the individual – the welder and their competencies, be it a trainee or a professional welder.
The basic document on which the S – K – S system is built is: IAB-089r4-12, IIW-IAB Section: "Minimum Requirements for the Education, Examination and Qualification of International Welder".
The system architecture consists of three main constituents:
Skills – acquisition of skills, i.e. mastering of welding technique.
Knowledge - knowledge acquisition, i.e. mastering of welding technology.
Stability - in the welding line of work represents the capability of frequent repetition of quality welds under demanded technology using the demanded technique in the demanded period of time on one's own or under supervision.

S – K – S
Skills – **K**nowledge – **S**tability

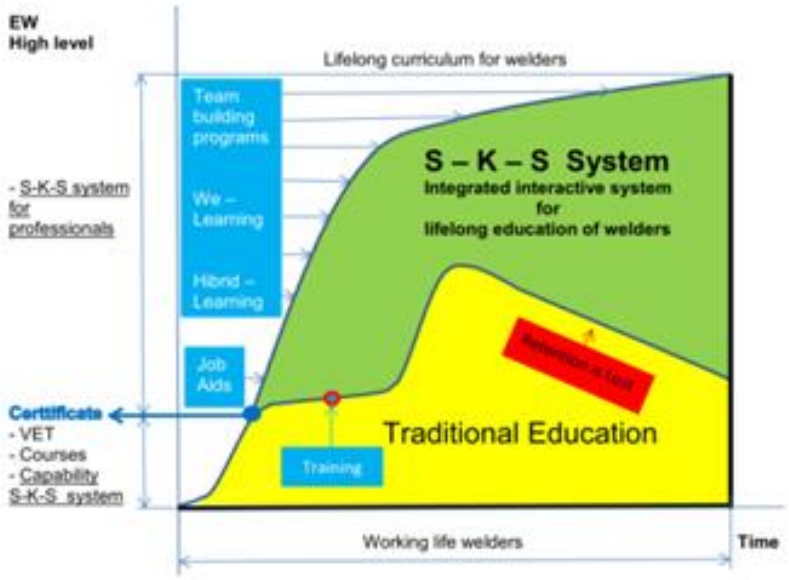


From the outline of the system depicted in figure it is visible that the concept of the system for lifelong education of welders consists of two parts:
1. Capability: S – K – S system for welding trainees, where one acquires competencies for welding in a specific process through different types of training: formal education, courses or any other formal, non-formal or informal way. After the training is completed, one obtains a Certificate on successfully completed training.
2. S-K-S system for professionals is a lifelong system of upskilling that needs to be repeated in specific time intervals in order to renew and upgrade all of the three system elements with individual welders and to harmonize them with the newest technical and technological trends.

Why is lifelong education of welders so important?

Lifelong education of welders, through the S-K-S system, has a significant influence on the quality of welded products and welders' life and work. Skills and knowledge, supplemented with the management of psychophysical and psychosocial risks, increase the work ability and mental stability of welders and have a direct impact on the life and work quality of welders.
This is why the S – K – S system promotes lifelong education directed towards the individual – the welder, a trainee and/or professional. This implies:

1. Adjustment of educational and teaching forms, methods and materials to the individual needs and capabilities of participants, in order to ensure the necessary competence level for European labor market,
2. Introduction of appropriate forms and methods of teaching and learning that will enable active and independent learning and practical application of the acquired knowledge,
3. Usage of different and relevant knowledge sources and teaching materials that enable participation, observation, independent research, experimenting, discovering, making conclusions, curiosity and learning how to learn,
4. Creation of positive environment that will interest and motivate the participants to learn and give them the sense of assurance and mutual respect,
5. Diagram outline of results of S-K-S system as opposed to the traditional one



Approach to lifelong education of welders

The S-K-S system promotes modern teaching, where one strictly takes care of the fact that the usage of appropriate pedagogical models and principles, as well as adequate means of communication with the teacher / mentor / instructor and among participants themselves is essential.
The S-K-S system leans on the **curriculum pedagogy.**
Structured and modular model was chosen as a teaching process model here. Namely, in the welding line of work, such a model is closely connected to EQF and provides the necessary horizontal and vertical passageway.
Hybrid (Blended) learning is a combination of the best teaching forms from both traditional and on-line education.
We-learning completely exploits the social component of learning.

Problem scale - conclusions

Following conclusions were reached in the document "Analysis of education, training and labor market system for welding trainees and professionals in partner countries with a reference to EU strategy":
1. Joining technologies will play a significant part in industrial production growth by the year 2020 (European Commission). Creation of a strong industrial foundation will follow the growth of hiring numbers and investments in the sector. The shortage of welders on the labor market is already evident. On the other hand, there are unemployed welders on the labor market - primarily because they lack competence.
2. Lack of welder competence is primarily connected to education that is not harmonized with good European practice and EWF recommendations, but also to the lack of continued welder education throughout their entire working life – the lack of lifelong education.
3. The classical way of teaching is still predominant in education and training, with certain exceptions. The emphasis is mostly on developing the skills, and not the capabilities.
4. Practically no significance is given to developing and maintaining the psychophysical abilities of welders.
5. The analysis has demonstrated that it is necessary to make a turn towards lifelong education and application of modern approaches and technologies in education while developing welder capabilities and competences and maintaining the same.



Who needs to get involved in finding the solution to the problem?

By examining the problem and thinking about it, it is evident that there should be a consortium, a cluster or some other kind of dynamic partnership founded between the business sector, industry, state institutions, universities, secondary vocational schools, welding societies, etc. with the basic assignment of adopting national criteria for welding standards. These standards should define competencies required by welders for specific processes and specific areas of work, minimum level institutions engaging in welder education of all levels should satisfy regarding equipment and personnel, redefine the age limit of welders for possible start of professional career or redefine the existing secondary school program, etc.
However, maybe the greatest responsibility lies with those who already have it - management of the welding companies.
If they accept the S-K-S system and initiate its implementation in their companies, in return they will get an increase in welding quality and gratitude of their welders.

S-K-S System

Skills

In general

SKILLS stand for acquisition of skills, i.e. mastering of welding techniques.
Trainees have to master a whole line of skill elements – welding technique in all positions, in order to be able to get certified and start working as professional welders upon completion of their education.
Professional welders very rarely renew their knowledge and welding technique during their working life. While they work, they mostly live in a closed circle: work – attestation – work – attestation.... And one loses the technique without the renewal of knowledge and training. To constantly weld does not guarantee top-of-the-line welding technique.
Mistakes in welding usually come from the badly chosen welding technology or the badly chosen welding technique. If the technology is left to the welding specialists (IWE; IWS or IWT), the poor performance (technique) is then left to the welders.
Welding skill needs to be at least kept to the appropriate level and then stream towards its improvement.
Welding technique cannot be maintained without regular training.
The S-K-S system predicts continued training throughout the entire working life of welders.
For trainees this would mean the acquisition of basic skills and the possibility to obtain their first certificate.
For professional welders this means continued training throughout their entire working life, at least to maintain/correct their welding technique.
A new element in training the welding skill is use of the VWTS (Virtual Welding Training System), a completely new technology based on the virtual reality.

Recommendation

When creating curricula, both on the VWTS and real welding machines, it is necessary to apply IIW Guideline for International Welder IAB-089r4-12 Part I: Minimum Requirements for the Education, Examination and Qualification and the suggested structured and modular learning system.
For Process 111 (MMA-welding) for ferritic and stainless steel these are Module E 1 to Module E 6.
For Process 135, 136 and 138 (MAG-welding) for ferritic and stainless steel these are Module M 1 to Module M 6.
For Process 131 (MIG-welding) for aluminum material groups these are Module MAl 1 to Module MAl 4.
For Process 141 (TIG-welding) for ferritic and stainless steel these are Module T 1 to Module T 6.
For Process 141 (TIG-welding) for aluminum material groups these are Module TAl 1 to Module TAl 6
For Process 311 (Gas-welding) for ferritic steel these are Module G 3 to Module G 6.

Skills for trainees

Practical assignments are divided into two types: virtual (40%) and real (60%). Virtual assignments are set by the mentor by designing the curriculum and determining the minimum threshold required for going to a higher level.
Real and virtual assignments are defined according to the already mentioned IIW-IAB Guidelines.
When creating curricula, special attention needs to be paid to the EQF – European Qualifications Framework or national QFs, learning outcomes and welder competencies for specific welding processes.
National QFs have to be harmonized with the EQF in order to obtain roughly equivalent learning outcomes and welder competencies at European level.
The suggested hours of training in IIW-IAB Guidelines are approximate.
The S-K-S system is flexible and directed towards the individual and their abilities. It ensures the passageway through the training both faster and slower than the assigned framework be it a training on the VWTS or real training.

Case study

Industrijsko-obrtnička škola Slavonski Brod – Croatia

Creation of student curricula, trainings and courses connected to the WPSs

Example 1

MAG – 135

1. Training

PB fillet joint 1 TRAINING – 1 IOS
Name of Curriculum: InteractivWeld Training - 1
Name of Course: Training - 1 IOS
The above-named training consists of two parts. The first part of the training pertains to the training of the skills on a virtual machine (40%), and the second part pertains to the same training, but on a real welding machine (60%). Both trainings are carried out according to the same WPS.

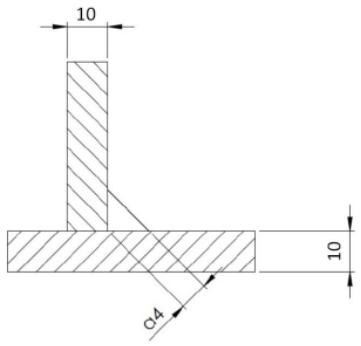
WELDING PROCEDURE SPECIFICATION (WPS)
Specifikacija postupaka zavarivanja(WPS)

TRAINING-1 IOS

Date: / Datum: Rev: / Rev:

Produced by: / Proizvođač:	IOŠ	Client: / Klijent:	InteractiveWeld
Project: / Projekt:	InteractiveWeld	Ref. stand: / Ref. Standard:	EN 287-1/ISO 9606-1
Location: / Mjesto:	SI. Brod	Exam body: / Isp. tijelo:	IOŠ-SI. Brod

Welding process / Postupak zavarivanja	1	135	2		3			
Shielding gas type / Vrsta zaštitnog plina		STARGON C18						
Weaving (Yes/No) / Njihanje(Da/Ne)		No / Ne max.: mm		max.: mm		max.: mm		max.: mm
Purging gas type / Vrsta plina za čišćenje		l/min						
Welding positions / Položaji zavarivanja		PB						
Joint type / Vrsta spoja		FILLET JOINT (KUTNI)						
Joint preparation / Priprema spoja								
Cleaning method / Postupak čišćenja								
Backing / Podloška		NE						
Single/double / Jednostruko/dvostruko		JEDNOSTRUKI „T"						
Back gouging / Žljebljenje		-						
Flux designation / Oznaka praška za zavarivanje								
Flux handling / Rukovanje praškom zazavarivanje								
Tungsten electrode / Volframova elektroda		mm						
Torch angle / Kut gorionika		8-12 °						
Stand.off distance / Udaljenost		6-14 mm						
Nozzle diameter(s) / Promjeri mlaznice		21 mm						
Tack. welding procedure / Promjena specifikacije zavarivanja		Rev: / Rev:						



Identification of parent metal
Identifikacija osnovnog metala

Part / Dio	Name/grade / Ime/kvaliteta	Standard / Standard	Group / Grupa	Delivery conditional / Stanje isporuke	Thickness range / Raspon debljine mm	Diameter range / Raspon promjera mm
I	1.1;1.2;1.4(S235JR)	CENISO/TR 15608	-	-	10,00	
II						
III						

Identification of filler metal
Identifikacija dodatnog metala

Index / Indeks	Trade name / Trgovačko ime	Classification/ Klasifikacija	Group / Grupa	Filler handling / Rukovanje dodatnim materijalom
1	MG-2	EN ISO 14341 A-G 424 C/MG3 51	-	
2				
3				

Welding parameters: / Equipment:
Parametri zavarivanja / Oprema:

Pass no. / Broj prolaza	Index / Indeks	Dia. / Promjer	Welding process / Postupak zavarivanja	Wire feed speed / Brzina žice	Current / Jakost struje, A	Voltage / Napon V	Current/polarity / Struja/polaritet	Welding speed / Brzina zavarivanja mm/min	Run –out length / Duljina depozita 1 elektrode, mm	Gas / Plin l/min	Heat input / Unos topline kJ/mm
1	1	1,20	135	7,50-8,00	230-250	25-26	DC(+)	-		12	-

Remarks / Primjedbe

Training 1- fillet weld in PB position, 1.st.layer-without weaving
Trening 1- kutno zavarivanje u PB položaju, 1 sloj-bez njihanja

Date/signature / Datum/potpis: 30.03.2014.
Approved / Odobrio

2. Implementation of student curricula, trainings and courses

Training on the virtual machine for MIG/MAG welding process encompasses 4 steps:
1. step: practicing handling the welding gun for the purpose of correct welding speed,
2. step: practicing handling the welding gun for the purpose of correct welding speed, taking into consideration the stick-out,
3. step: practicing handling the welding gun for the purpose of correct welding speed, taking into consideration the stick-out and inclination angle of the welding gun
4. step: practicing welding process through invariable and ideal welding parameters.

Working principle is such that you cannot move to the next step until you have achieved the minimum test score set in the curriculum (60%).
Training on the virtual machine for MMA welding process encompasses 4 steps:
1. step: practicing igniting the rod electrode at the correct tilt angle and following the specified ignition sequence – ignition attempt:4; threshold: 50%,
2. step: practicing the manipulation of the road electrode at the right speed in the right position, threshold: 60%
3. step: practicing the correct welding speed, arc length and correct manipulation of electrode holder at the appropriate angle, threshold: 60%
4. step: practicing with fixed and ideal welding parameters, threshold: 60%

Working principle is such that you cannot move to the next step until you have achieved the minimum test score set in the curriculum.

The above-mentioned trainings follow one another, this means that the student has to achieve satisfactory results in order to be allowed to continue with the next training and successfully finish the entire curriculum.
Once the student has successfully mastered the whole curriculum on the virtual machine, they start welding on real welding machines according to the exact same WPS.
In order to achieve better results with training on the WVTS, the students are divided into small groups (max. 5 students). Welding on real machines is carried out according to the principle - one student, one machine.

3. Evaluation of student curricula, trainings and courses

Monitoring and evaluation of trainees' welding competence - training on VWTS:
- monitoring and evaluation of results of the achieved welding speed/igniting, stick-out and inclination angle
- monitoring and evaluation of results achieved after the carrying out of simulation concepts
- monitoring and evaluation of the final result after the carrying out of the training

Monitoring and evaluation of trainees' welding competence - training on real welding machines:
Monitoring and evaluation of the student's practical work through 4 elements:
- insufficient penetration
- porosity
- undercuts
- a = measure (FW)

Practical assignments are marked according to the standard EN ISO 5817.
Test criterion ISO 5817

Group	B	5 Points
Group	D	4 Points
Group	C	3 Points
N e		Not passed

Skills for professional welders

Professional welders very rarely renew their knowledge and welding technique during their working life. While they work, they mostly live in a closed circle: work – attestation – work – attestation.... And one loses the technique without the renewal of knowledge and training. To constantly weld does not guarantee top-of-the-line welding technique.
Mistakes in welding usually come from the badly chosen welding technology or the badly chosen welding technique. If the technology is left to the welding specialists (IWE; IWS or IWT), the poor performance (technique) is then left to the welders.
The research and pilot program have shown that welders regain their technique through training, which automatically reduces the percentage of defects.
The Skills part for professional welders is based on:
- training of welders on VWTS – Virtual Welding Training System 100%, at least once a year, regardless of attestation.

Why 100% on VWTS?
Professional welders engage in real welding every day. Training on the VWTS enables them to bring their technique back to the acceptable scope in a very short period of time, and the use of the replay feature gives them instant feedback into their mistakes.

Recommendation
Curriculum for professional welders is created according to the tailor-made principle.
The employer defines all the important elements connected to their welding technology and the applied welding techniques. Training curriculum is defined accordingly.
Curriculum implementation procedure is:
1. Initial testing of welders before implementation of curriculum,
2. Training of welders on VWTS
3. Final testing – evaluation of level of efficiency in correction of welding technique
4. Monitoring of training results in production.

Case study

Končar Metalne konstrukcije, Zagreb Croatia

Creation, implementation and evaluation of curricula, trainings and courses for professional welders

1. Training concept on the VWTS

Training concept on the VWTS encompasses:

- initial testing of candidates on the VWTS – simulation concept (3D weld) at the level of 65%
- training of candidates on the VWTS - training concept for welds in different positions at the level of 65%
- final testing of candidates on the VWTS – simulation concept (3D weld) at the level of 65%

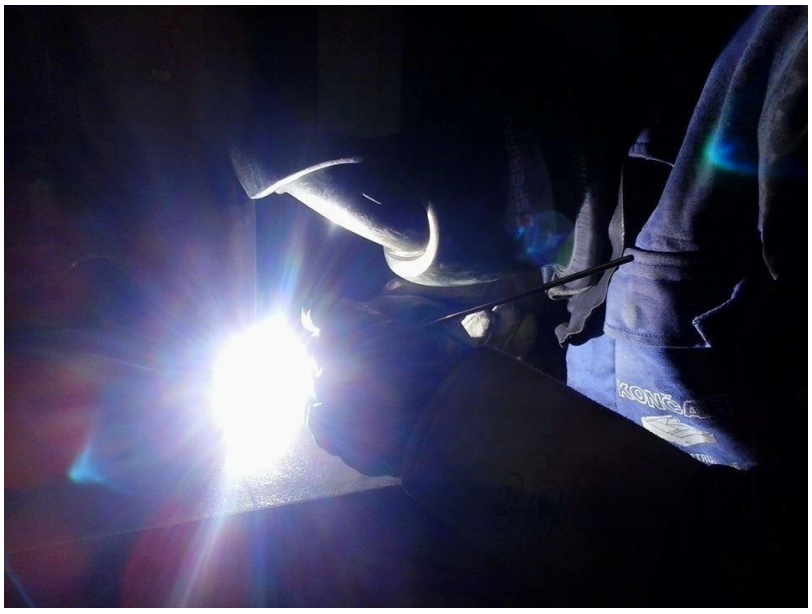
Trainings for professional welders are carried out for the purpose of correction of their welding technique.
The trainings are done exclusively on the VWTS (training share 100%).
The training concept on the VWTS is designed according to the company needs - Tailor Made principle (processes, welded joint type, welding positions).

2. Monitoring and evaluation

The monitoring and evaluation of welder's competence achieved through the training on the VWTS will be carried out as follows:

- monitoring and evaluation of results achieved by initial testing
- monitoring and evaluation of results achieved by training
- monitoring and evaluation of results achieved by final testing
- monitoring of the training influence in real working conditions until first weld defects emerge

Additional ways of monitoring and marking are arranged according to the needs and demands of individual companies.



Knowledge

In general

KNOWLEDGE stands for knowledge acquisition, i.e. mastering of welding technology.
In today's time, when new materials appear on a daily basis and when technological procedures are getting more complex, welder's knowledge is an important factor in quality of welding jobs. Understanding the welding process during its execution reduces the possibility of defects to a minimum. Those who know more, make fewer mistakes. By repeating, one strengthens the teaching matter, and its upgrading raises the level of quality in welding. In other words, one needs to learn.
Knowledge sources are partly traditional, and mainly modern, associated with Internet use, web pages with e-learning materials and welding sites. Facebook was chosen as means for communication because of its wide spectrum of possibilities for communication and immense popularity within the student population, but also because all students have mobile phones, and Facebook use is free of charge. Mobile devices such as smartphones and tablets that are very popular now are used as means of communication. Primarily for the reason that in such a way information is attainable anytime, anywhere.
Coordination of all activities is run via mentorship.

Recommendation

When creating curricula, both on the VWTS and real welding machines, it is necessary to apply IIW Guideline for International Welder IAB-089r4-12 Part I: Minimum Requirements for the Education, Examination and Qualification and the suggested structured and modular learning system.
For theoretical education: Module A + Module B + Module C.
Modules S: dedicated to one specific welding process.
- SG.1 Construction and maintenance of gas welding equipment & typical welding parameters.
- SG.2 Welding consumables.
- SG.3 Health and safety.
Module SA: Supplementary theoretical education for MMA welding.
Modules SM: Supplementary theoretical education for MIG/MAG welding.
Module ST: Supplementary theoretical education for TIG welding.
Modules P, dedicated to one specific material.
Module PAL: Instruction items for supplemental theoretical education for aluminum.

Knowledge for trainees

Knowledge for trainees is based on the combination of off-line and on-line knowledge acquisition - ratio 50% : 50%.
The guide for welder education is previously mentioned IIW Guideline for International Welder IAB-089r4-12 Part I: Minimum Requirements for the Education, Examination and Qualification.
Theoretical education runs on the modular principle, where modules are chosen so that they correspond to the specific welding processes. Here, it is crucial that the mentor be familiar with the participants and their previous knowledge, so that they can adjust the duration of education accordingly. It is important to stress that it takes more time than stated in the Guidelines for trainees without significant previous knowledge. They require a pre-module before entering this type of education where they can acquire enough knowledge or education in metal working in order to follow the course required.
During the education process the mentor explains the basic elements of theoretical training face to face, and upgrade is done with the help of internet and mobile devices using adequate web pages. Communication between: mentor - participant, participant - participant is done with the help of social networks (e.g. Facebook) or through e-mail.
In such a way one achieves an optimal combination of formal and informal learning, more suitable for younger population.
This system constituent also makes use of the VWTS, in a way that theoretical contents are inserted into the system. After education a quiz is created to evaluate the knowledge of each individual in theoretical part.
The structure of theoretical education, apart from the IIW Guidelines, also needs to be directed towards:
- Professional language competence in native tongue and at least one foreign language,
- Mathematical competence and
- Vocational/professional competence where it should be insisted not only on welding, but especially on reading technical drawings and technological documentation (WPS).

Case study

Industrijsko-obrtnička škola Slavonski Brod – Croatia
Program dvogodišnjeg školovanja učenika-zavarivača

Subjects	1st year hrs	2nd year hrs	Total hrs
I General education			
Croatian language	85	70	**155**
Information technology	68	-	**68**
Physical education	51	42	**93**
Religion/Ethics	34	28	**62**
Total I:	**238**	**140**	**378**
II Vocational theoretical part			
Foreign language	34	28	**62**
Entrepreneurship	-	28	**28**
Mathematics (occupational)	68	28	**96**
Welding	68+	12+	**80**
Occupational safety	16		**16**
Welding - extra hours	86+	184*	
Total II	**272**	**280**	**552**
Total I + II	**510**	**420**	**930**
III Practical part			
Practical education	440**	573**	**1013**
Practical education - extra hours	64		**64**
Total I + II + III	**1014**	**993**	**2007**

Legend:
\+ lessons are executed 50% in a classical way, and 50% by we - learning method
* lessons are executed on the VWTS
** lessons are executed 40% on the VWTS, 60% in a classical way

	Subjects completely harmonised with the IIW Guidelines
	Subjects harmonised with the S-K-S system
	Subjects according to the Croatian syllabus

Knowledge for professional welders

Knowledge for professional welders is based on combination of off-line and on-line knowledge renewal and acquisition of new knowledge within the lifelong learning process 20% : 80%. This ratio in knowledge acquisition is going to change to 100% on-line in the next ten years, when we have a generation of professionals who went through the S – K – S system education.
This part of lifelong education runs on the tailor-made principle. Educational needs are further defined with the management of welding companies.
Knowledge level of each individual is established after the initial testing, and depending on the results, a curriculum for knowledge renewal and its duration is created.
After the final testing the knowledge is evaluated and, if necessary, corrective measures taken.
Here one has to bear in mind that knowing welding technology and understanding the process itself is of great significance for welding quality.

Stability

In general

Stability in the welding line of work represents the capability of frequent repetition of quality welds under demanded technology using the demanded technique in the demanded period of time on one's own or under supervision.
IAB Guideline article 2 *Access to the course* it is stated: "For entry to the module 1, appropriate health, physical and mental capability is assumed".
Partner consortium of the EU Leonardo da Vinci project InteractivWeld agrees with the previous sentence with an addition: health, physical and mental capability needs to be maintained throughout the entire professional life of welders. This is why a foundation is needed we like to call Stability.
Psychophysical stability is an important factor in any line of work. Psychophysical stability in welding is a big step forward regarding welding quality and prolonging the professional life of welders. Aerobic training raises the aerobic ability which represents the ability of a body to create energy necessary for physical work. This type of training not only provides the strength necessary for easier execution of work, but also the stability in expected results, which increases the quality of living prolongs the personal and professional life of welders. In other words, one needs to keep fit and motivated.
Each trainer needs to develop such aerobic training that it can be used anywhere and in any place.
This primarily pertains to the aerobic training and relaxation after and during hard work.
The basic goal is to create the necessary habits and awareness of usefulness of exercising with young people during formal education. With older welders the habit needs to be created through a scholastic system supported by the employers and through regular team building programs.

Recommendation

Stability for trainees

Stability for trainees is based on aerobic training in real conditions and on-line fitness or aerobic, ratio 50% : 50%.
Firstly, what needs to be explained is that during initial education marked with C – Capability on InteractivWeld logo the S-K-S system for trainees takes place. In this system Stability plays a significant role in creation of long-term habits of aerobic training with welding population.
Welders acquire basic knowledge of the training concept they need and relaxation ways during and after work in a formal cycle. In informal cycle (other 50%) they lean on creation of their own concept by applying the knowledge from the previous cycle with the help of internet, social networks and mobile technology, with a big help from the mentor, of course.

Stability for professional welders

Stability for professional welders is based on fitness or aerobic exercises adjusted for welders 100% on-line.
This part of the S-K-S program is the most delicate because it requires breaking through two barriers:
The first barrier represents professional welders and their way of life and work, and acceptance of aerobic training as an integral part of their everyday life,
The second barrier is the employers who find it very hard to accept such suggestions. What matters, is the job, production execution and workers who are supposed to execute it. Each further activity creates problems they do not want and eventually, takes away some part of their profit.
During research and pilot program we came to the conclusion that where there is interest shown by the management, the welders (workers) accept the activities very quickly, too. Part of the research and pilot program that was carried out in welding companies has confirmed this finding.
Including the management in any type of activity that brings the workers some kind of progress, motivates the workers and has a positive impact on all production elements, but mostly on product quality.

Case study

Industrijsko-obrtnička škola Slavonski Brod – Croatia

Exercises

Working out is done one hour twice a week in the gym with professional guidance and control
An hour exercise consists of:

- Introductory part – Stretching and warm up
- Main A part - Aerobic exercises, especially sports games
- Main B part - Developing of repetative strength and stamina
- Final part - Relaxation, stretching and self-massage

Twice a week on one's own at home.
Exercising based on aerobic training.
Each individual was tested and given an individual exercise programme.

The exercises were chosen in such a way that they have an impact and can ensure progress on:

1. Locomotive system by increasing: the strength, the stamina and the flexibility
2. Cognitive-conative system by developing: the coordination, the balance and the feeling and body control in time, space and rhythm
3. Cardiovascular system: by developing the lung and hearth capacity and increasing the vascularization of the whole body
4. Mental Relaxation And Increase In: motivation, confidence, optimism and joy

When developing the functional abilities, everything is done by measuring the pulse
measure the puls while keeping still – after getting up, three days in a row, then take the middle value
Beginners work with 60% intensity- it is calculated as follows:

A person is 40, their puls while still is 85.
1. 220 – 40 = 180
2. 180 – 85 = 95
3. 60% of the score under 2. is 57
4. 57 + 85 = 142
this means that the person has to exercise with the puls of 142

When developing the repetitive strength, stamina and flexibility.
One has to pay attention to technique of exercise execution and breathing technique.

Recommendations

In general

To use the S-K-S system means:

- To update the knowledge and skills throughout the entire working life of a welder,
- Aerobic training (exercising) has a considerable influence on maintaining the physical capacity of a welder. Due to ageing it drops very quickly, which is prevented this way.
- Maintaining the physical ability of a welder is not only health connected, but also to their competencies, values, working environment and social relationships.
- Mental capacity needs to be supported first of all because of the rapid and constant change at the work place as a result of information technology usage and globalization
- Support from the employers is a considerable factor of influence on welder's working abilities. Psychosocial factors, such as mental requirements at work, degree of control, deadline pressure and attitude of company management are of utmost importance.

For trainees

Education systems for trainees need to be based on the newest and IT technologies and have to keep pace with time.
Only modernly designed education programs and good promotion of competencies that come out of this profession are attractive to young people.
Use of mobile devices, the internet and VWTS is not only modern, but also highly efficient.
In this way, education systems become: flexible, of good quality, continuous, compatible, dynamic, open and available.
By integrating the S-K-S system into education programs for trainees one obtains a solid foundation, uniform and standard competencies and equal opportunities for all trainees in their professional work.

For professional welders

Continued training of knowledge and skills, but also exercising is very important in order for professional welders to be able to increase and not only maintain their physical ability.
Company management has an important role in this process.
If companies alongside work also introduce team building programs for welders and display constant care of development of all the elements within the S-K-S system, the results will present themselves. The expected results are, on one hand, satisfaction of employees, and on the other raising the quality of welded products.

Recommendations for the implementation of S-K-S System for the Welder education within the EWF Qualification System

The S-K-S approach tackled within the InteractivWeld project is in fact a trifecta that covers the three main aspects within the most demanding jobs, like welding. S-K-S stands for Skill, is essential to a good performance in welding that allows for a work with less defects and less rework, Knowledge, allows to adjust to unusual situations and resolve unexpected situations due to the fact of having knowledge to adapt, and finally Stability, necessary to have less fatigue and more consistency in the work developed which on the other hand leads to less sick leave days due to injuries (ergonomic injuries).
To use the S-K-S system means:

- To update the knowledge and skills throughout the entire working life of a welder,
- Aerobic training (exercising) has a considerable influence on maintaining the physical capacity of a welder. Due to ageing it drops very quickly, which is prevented this way.
- Maintaining the physical ability of a welder is not only health connected, but also to their competencies, values, working environment and social relationships.
- Mental capacity needs to be supported first of all because of the rapid and constant change at the work place as a result of information technology usage and globalization
- Support from the employers is a considerable factor of influence on welder's working abilities. Psychosocial factors, such as mental requirements at work, degree of control, deadline pressure and attitude of company management are of utmost importance.

Recommendations for Welding Training Schools and Trainees

Education systems for trainees need to be based on the newest and IT technologies and have to keep pace with time.
Only modernly designed education programs and good promotion of competencies that come out of this profession are attractive to young people.
Use of mobile devices, the internet and VWTS is not only modern, but also highly efficient. In this way, education systems become: flexible, of good quality, continuous, compatible, dynamic, open and available.
By integrating the S-K-S system into education programs for trainees one obtains a solid foundation, uniform and standard competencies and equal opportunities for all trainees in their professional work.
For young to be welders the use of new technologies is an added incentive to their training, namely theoretical didactic training materials and virtual welding systems for practical training. This approach ca also be a way for training schools to give more efficient courses and in the long run, reduce the operational costs of practical training in welding.

Theoretical and didactic welding materials

During the course of the InteractivWeld project several e-materials were used in welder courses in Croatia to support the students:

- http://www.millerwelds.com/resources/etraining.html
- http://www.lincolnelectric.com/en-us/education-center/training-materials/Pages/training-materials.aspx
- http://www.hobartwelders.com/elearning/
- http://www.welding-courses.net/
- http://www.gsi-elearning.de/en/courses/welding-engineerswelding-technologists/
- http://www.e-weldingandfabrication.com/

Within the scope of the project a study was made in order to compare the contents of the above e-materials to the requirements of the EWF guideline for welders (EWF-IAB-089). The findings can be found bellow.

Module A: Base theoretical education for fillet welder			
Subjects		**Material Analysed**	**Comments**
A.1	Using electricity for arc welding	http://www.millerwelds.com/resources/basicelec/ http://www.lincolnelectric.com/en-us/education-center/training-materials/Pages/training-materials.aspx http://www.hobartwelders.com/elearning/	Only gives an introduction to electricity, power sources and small information about the arc and terminology and introduction to welding processes but not the whole objectives are met. Missing more detail for electric arc as heat source and metal transfer, weld pool.
A.2	Welding equipment	Demo GSI E Learning for MIG/MAG http://www.lincolnelectric.com/en-us/education-center/training-materials/Pages/training-materials.aspx http://www.millerwelds.com/resources/basicMIG/index.html http://www.millerwelds.com/resources/bookspamphlets.html	Gives a good introductory panorama of the power sources and everything related with them.

A.3	Health and Safety	http://www.millerwelds.com/resources/bookspamphlets.html http://www.lincolnelectric.com/en-us/education-center/training-materials/Pages/training-materials.aspx	Gives a good panorama of the health and safety issues.
A.4	Safe working in the fabrication shop	http://www.millerwelds.com/resources/bookspamphlets.html http://www.lincolnelectric.com/en-us/education-center/training-materials/Pages/training-materials.aspx	Information available not very detailed. Gives only an introduction. Lacks effective responses to each danger and solutions to minimize exposure to dangers.
A.5	Welding consumables	http://www.millerwelds.com/resources/bookspamphlets.html http://www.lincolnelectric.com/en-us/education-center/training-materials/Pages/training-materials.aspx http://www.hobartwelders.com/elearning/	Information available not very detailed. Gives only an introduction. Lacks shielding gas information and influence. Storage information.
A.6	Welding practice (1)	No useful information was found.	
A.7	Welding practice (2)	http://www.millerwelds.com/resources/bookspamphlets.html	Information available not very detailed. Gives only an introduction. Lacks link to imperfection standards,
A.8	Introduction to steel	No useful information was found.	
A.9	Qualification of welders	No useful information was found.	

Module B: Base theoretical education for butt welder			
Subjects		**Material Analysed**	**Comments**
B.1	Methods of joint preparation for welding	No useful information was found.	
B.2	Welded joints in plates	http://www.millerwelds.com/resources/bookspamphlets.html http://www.lincolnelectric.com/en-us/education-center/training-materials/Pages/training-materials.aspx http://www.hobartwelders.com/elearning/	Information available not very detailed. Gives only an introduction.
B.3	Weldability of steels	No useful information was found.	
B.4	Shrinkage, residual stress, distortion	No useful information was found.	
B.5	Weld imperfections	http://www.millerwelds.com/resources/bookspamphlets.html	Lack of information on the influence of imperfections on the product. Fatigue influences.
B.6	Overview of fusion welding processes	http://www.hobartwelders.com/elearning/	List almost all the processes, but does not give a general panorama.
B.7	Safe working on site	http://www.e-weldingandfabrication.com/demo.html http://www.millerwelds.com/resources/etraining.html	It is lacking. It could be more detailed.
B.8	Inspection and testing	No useful information was found.	
B.9	Quality Assurance in welding (QA)	No useful information was found.	

Module C: Base theoretical education for tube welder			
Subjects		**Material Analysed**	**Comments**
C.1	Welded joints in pipes	http://www.millerwelds.com/resources/bookspamphlets.html	Information available not very detailed. Gives only an introduction.
C.2	Materials other than non-alloy steel	No useful information was found	.
C.3	Review and consequences of failures	No useful information was found.	
C.4	International Welding Standards	No useful information was found.	

Module SA: Supplementary theoretical education for MMA welding (111)			
Subjects		**Material Analysed**	**Comments**
SA.1	Construction and maintenance of MMA welding equipment & typical welding parameters	http://www.lincolnelectric.com/en-us/education-center/training-materials/Pages/training-materials.aspx http://www.hobartwelders.com/elearning/ http://www.millerwelds.com/resources/bookspamphlets.html	Maintenance of MMA equipment is lacking. Notion of open circuit voltage.
SA.2	Covered electrodes	http://www.hobartwelders.com/elearning/	OK
SA.3	Health and safety	http://www.millerwelds.com/resources/bookspamphlets.html	OK

SM: Supplementary theoretical education for MIG/MAG welding (13)			
Subjects		**Material Analysed**	**Comments**
SM.1	Construction and maintenance of MIG/MAG equipment	Demo GSI E Learning for MIG/MAG http://www.millerwelds.com/resources/bookspamphlets.html http://www.millerwelds.com/resources/basicMIG/index.htm	Maintenance of MIG/MAG equipment is lacking. Influence and selection of consumables in welding is lacking.
SM.2	Welding consumables	http://www.hobartwelders.com/elearning/	OK
SM.3	Health and safety	http://www.millerwelds.com/resources/bookspamphlets.html http://www.millerwelds.com/resources/basicMIG/index.htm	OK
SM.4	MIG/MAG welding characteristics and typical welding parameters	Demo GSI E Learning for MIG/MAG http://www.lincolnelectric.com/en-us/education-center/training-materials/Pages/training-materials.aspx http://www.millerwelds.com/resources/basicMIG/index.htm http://www.millerwelds.com/resources/bookspamphlets.html	OK

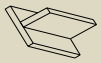
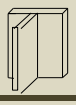
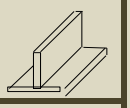
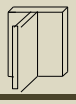
ST: Supplementary theoretical education for TIG welding (141)			
Subjects		**Material Analysed**	**Comments**
ST.1	Construction and maintenance of TIG welding equipment	http://www.lincolnelectric.com/en-us/education-center/training-materials/Pages/training-materials.aspx http://www.hobartwelders.com/elearning/	Maintenance of TIG equipment is lacking. Lacking on welding imperfections for TIG. Notion of open circuit voltage.
ST.2	Tungsten electrodes and welding consumables	No useful information was found.	
ST.3	Health and safety	http://www.millerwelds.com/resources/bookspamphlets.html	OK

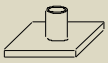
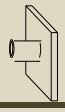
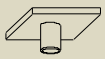
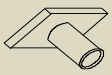
After analysis it can be concluded that the e-materials analysed within the project cover between 30 to 40% of the EWF welder syllabus and can be used as a guide to training schools and students to see which subjects are lacking in terms of e-materials.
It can also be a tool to define a task for the students to try and find more e-materials online for specific subjects, providing to the students the necessary tools to initiate a we-learning methodology.

Practical Training in Welding

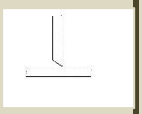
From the results of the InteractivWeld project it can be demonstrated that for welder practical training better results can be achieved in a blended learning scenario where virtual welding is used as a training tool replacing the use of real welding machines in the initial phase of new exercises.
The use of virtual welding machines in practical training it is still in an initial state and as more and more training centres adopt this new technology, it's only natural that new recommendations appear. But from the experience achieved within the project and based on a study from the Spanish Welding Society (CESOL) one of the methodologies to follow is to use virtual welding in the beginning of each exercise in order to the student adapt to the new welding conditions, and only after the student achieves a defined threshold he is allowed to weld in physical welding machines.
It was also demonstrated that by using virtual welding a training centre can save on resources over 50% in terms of operational costs, because it allows the students to make mistakes in a virtual environment before going to the physical welding machines.
The following recommendations are for welder training schools who are implementing the EWF welder qualification and are considering the use of virtual welding machines in practical training. The example is for the MIG/MAG process for the fillet and butt welder levels, but it can also be used for other welding processes where virtual welding is available.

M 1	**Practical training**				
No.	**Type of weld**	**Recommended material thickness [mm]**	**Welding position**	**Sketch**	**Recommendations**
1	Introduction				Practical Demonstration from the teacher on how to operate both virtual and physical welding machines for the welding positions addressed in the module: • Adjust the machines to fit the correct welding parameters; • Manipulation of welding torch; • Consumables used; • Specimen preparation and assembly; • Correct posture when welding.

No.	Type of weld	Recommended material thickness [mm]	Welding position	Sketch	Recommendations
2	Bead on plate	Unlimited	PA / PF / PG		Use of virtual welding machines only, to properly control welding variables: • Maintain welding speed defined; • Maintain proper welding torch orientation; • Maintain recommended stick-out; • Maintain arc length. After achievement the objective set out in the virtual welding machines, the student can pass to the following exercises in other welding positions.
3	Fillet weld, T-joint	t > 1	PA		Use of virtual welding machines in the initial part of each exercise to properly control welding variables, using evaluation tools provided by virtual welding machine: • Maintain welding speed defined; • Maintain proper welding torch orientation; • Maintain recommended stick-out; • Maintain arc length. Use of physical welding machines only when the above variables are properly controlled (set thresholds to proceed to physical welding machines). Make two weld specimens in physical welding machines.
4	Fillet weld, T-joint	t > 1	PB		
5	Fillet weld, T-joint	t > 1	PG		
6	Fillet weld, corner joint	t > 1	PG		
7	Fillet weld, T-joint	t > 8	PB		
8	Fillet weld, T-joint	t > 8	PF		
9	Fillet weld, T-joint	t > 8	PD		

M2	Practical training				
No.	**Type of weld**	**Recommended material thickness / diameter [mm]**	**Welding position**	**Sketch**	**Virtual Welding Recommendations**
1	Introduction				Practical Demonstration from the teacher on how to operate both virtual and physical welding machines for the welding positions addressed in the module: • Adjust the machines to fit the correct welding parameters; • Manipulation of welding torch; • Consumables used; • Specimen preparation and assembly; • Correct posture when welding.
2	Fillet weld, Tube to plate	t > 3 D ≥ 40	PB		Use of virtual welding machines in the initial part of each exercise to properly control welding variables, using evaluation tools provided by virtual welding machine: • Maintain welding speed defined; • Maintain proper welding torch orientation; • Maintain recommended stick-out; • Maintain arc length. Use of physical welding machines only when the above variables are properly controlled (set thresholds to proceed to physical welding machines). Make two weld specimens in physical welding machines. If after visual inspection the specimens are not ok, student has to return for virtual welding to improve on the operational method. When improvement has been achieved only one physical specimen should be done.
3	Fillet weld, Tube to plate	t > 3 D ≥ 40	PH*		
4	Fillet weld, Tube to plate	t > 3 D ≥ 40	PD		
5	Fillet weld, Tube to plate	t > 3 D ≥ 40	PD		
*According to ISO 6947:2011 welding position PF for tubes has been changed to test position PH covering PE, PF and PA.					

M3	Practical training				
No.	**Type of weld**	**Recommended material thickness [mm]**	**Welding position**	**Sketch**	**Virtual Welding Recommendations**
1	Introduction				Practical Demonstration from the teacher on how to operate both virtual and physical welding machines for the welding positions addressed in the module: • Adjust the machines to fit the correct welding parameters; • Manipulation of welding torch; • Consumables used; • Specimen preparation and assembly; • Correct posture when welding.
2	Butt weld	t > 1	PA		Use of virtual welding machines in the initial part of each exercise to properly control welding variables, using evaluation tools provided by virtual welding machine: • Maintain welding speed defined; • Maintain proper welding torch orientation; • Maintain recommended stick-out; • Maintain arc length. Use of physical welding machines only when the above variables are properly controlled (set thresholds to proceed to physical welding machines).
3	Butt weld	t > 1	PG		
4	Butt weld	t > 8	PA		
5	Butt weld	t > 5	PC		Make two weld specimens in physical welding machines. If after visual inspection the specimens are not ok, student has to return for virtual welding to improve on the operational method. When improvement has been achieved only one physical specimen should be done.

M 4	Practical training				
No.	**Type of weld**	**Recommended material thickness [mm]**	**Welding position**	**Sketch**	**Virtual Welding Recommendations**
1	Introduction				Practical Demonstration from the teacher on how to operate both virtual and physical welding machines for the welding positions addressed in the module: • Adjust the machines to fit the correct welding parameters; • Manipulation of welding torch; • Consumables used; • Specimen preparation and assembly; • Correct posture when welding.
2	Butt weld	t > 1	PE		Use of virtual welding machines in the initial part of each exercise to properly control welding variables, using evaluation tools provided by virtual welding machine: • Maintain welding speed defined; • Maintain proper welding torch orientation; • Maintain recommended stick-out; • Maintain arc length. Use of physical welding machines only when the above variables are properly controlled (set thresholds to proceed to physical welding machines). Make two weld specimens in physical welding machines. If after visual inspection the specimens are not ok, student has to return for virtual welding to improve on the operational method. When improvement has been achieved only one physical specimen should be done.
3	Butt weld	t > 5	PE		
4	Butt weld	t > 8	PF		
5	Single bevel butt weld, T-joint	t > 5	PB		
6	Single bevel butt weld, T-joint	t > 5	PD		
7	Single bevel butt weld, T-joint	t > 5	PF		

We would like to thank all the partners for their contribution to project results.

A special thanks goes to everybody who, along with their everyday jobs and activities, made a great effort to make the project successful.

THANKS

IOS	EWF	GSI SLV	SVS	FRONIUS	KMK
Mirta Szügyi	Tobias Rosado	Karina Sydekum	Anja König	Josef Kreindl	Robert Vidas
Edita Margeta	Italo Fernandes	Bastian Sikora	Mariano Santoro	Jürgen Wirnsperger	Goran Grgić
Goran Adelsberger	Eurico Assunção	Klaus Billen	Dr. Marc Harzenmoser		Nusret Šuvalić
Ana Konjatić	Luisa Coutinho	Uwe Koppel	Kim Ehrler		Mario Orač
Željko Krijan	Heliana Bibas		Wolfgang Ahl		Denis Bjelivuk
Ivo Orešković	Bernardo A. Hourmat		Nikolaus Brunner		Damir Očić
Vlado Maurović			Jacques Herrgott		Stjepan Menjak
Gordana Potnar Matković			Roger Rada		Zdravko Jurički
Ines Delhusa			Sladjana Jonovic		Marin Ćorluka
Suzana Mihelčić					Tin Ahmetović
Dalibor Velički					Dražen Kasunić
Ivana Rajić Pilipović					Goran Burazer
Marta Živatović					Anto Šakić
Luka Mladinović					Tomislav Cimaš
Ankica Gačić					Danijela Dekanić
					Davor Bakša

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This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.
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