

# **Innovative Training Methodology, In Occupational Risk Prevention, For Welding Tasks in Metal Structures**

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**Abstract** – In this research an analysis is made with a preventive perspective of an activity within the metal sector, specifically of the activities of welding metal structures. The activities and risks involved in the welding of metal structures will be analysed, detecting the existing training deficiencies, establishing training objectives and strategic lines that allow the design and planning of a training plan to be carried out. It is undeniable the important role played by the training of workers in the prevention of occupational hazards to combat existing risks. The improvement of health, safety, working conditions and the accident rate, which currently stands at 650000 occupational accidents with sick leave. As well as to establish a culture of prevention, taking into account that the elaboration of the training plan contemplates the achievement of the training objectives established according to the deficiencies detected. The planning, timing and execution of the training actions that make up the plan, the follow-up and maintenance of the contents, and the evaluation of the workers who take it are the blocks that will make up the training plan.

**Keywords:** Metal structure, Training plan, Training gaps, Motivational elements, Assessment.

## **1. Introduction**

Within the metal sector, the activity to which the welding of structures belongs according to CNAE [1] is found within the alternative "Industry" and belongs to code 2511: Manufacture of metal structures and their components. CONFEMETAL [2], states that a total of 25597 workers carry out their activity in the manufacture of metal structures and their components.

Derived from this activity, as far as occupational accidents are concerned. The INSST [3] indicates that, in Spain, during 2019 (choosing this year to save data gaps caused by the Covid), 650602 occupational accidents with sick leave were recorded. It is for this reason that the entire training and educational sphere tries to promote and acquire knowledge in the field of occupational risk prevention among workers. This is a challenge and a tool, which companies and institutions must internalise as a priority item throughout the organisation of these companies and institutions.

Training in occupational risk prevention (ORP) in Spain is regulated and made compulsory by current legislation [4]. Article 19 of this law establishes the obligation of the employer to guarantee all workers sufficient and appropriate training on the specific occupational hazards of their job. And specifically, as this is training for workers in the metal sector, this ORP training is regulated by its own regulations [5], [6]. This agreement is within the state regulatory framework for ORP. This agreement establishes that the Metal Training Foundation (MTF) will develop and manage the training programmes, as well as the specific contents to be included.

Despite being aware of the obligatory nature and the crucial role played by training in occupational risk prevention, the perception held by a large part of the community is that the training they receive is of little value in terms of usefulness and quality. This training is seen by the management of the company or institution as a mere formality or requirement to be fulfilled in order to be able to continue or develop their work. As D. Cobos and A. Garí [7] said, "The training that is currently provided does not respond, in many cases, to the real needs of workers and, in general, of the organisation". This is still the case today. More current studies [8] conclude that it is necessary to promote more practical ORP training adapted to the reality of companies and workers, orienting it towards a preventive culture. It is necessary to improve and update the methods, tools and materials used in such training, taking advantage of new technologies. Another more recent and specific study [9], focused on welding tasks in the field of construction, concludes that there are training needs in practically all the competences associated with the work of a welder that should be addressed as a matter of urgency.

The main objective of this research is the development of a training plan for welding metal structures, specifically for welding light structures in the factory. The aim is to design an effective, inclusive and sufficient plan that manages to internalise the culture of prevention in the students. In order to draw up this training plan, the different activities involved in the welding of metal structures were studied and the main risks were analysed from a hygienic, ergonomic and psychosocial point of view. Analysing causes, consequences and preventive measures. A series of training needs will be established, which will have the role of training objectives to be fulfilled in the design and preparation of this training plan. The design and elaboration of the training plan will be carried out following a training strategy, which will structure the training plan and provide it with efficiency through motivational elements.

## **2. Methodology O Case Study**

In order to design and draw up this training plan, the first step is to identify the specific risks of the activity. Distinguishing between risks and factors. Classifying them by safety, hygienic, ergonomic and psychosocial risks.

The training deficiencies that this study aims to solve are established by the combination of the author's professional experience in the sector, specifically with the results of other studies consulted in the state of the art. Evidence of these shortcomings in training in occupational risk prevention and lack of information on the part of workers was obtained, which resulted in risks and accidents and made training needs evident.

From the training point of view, training in occupational risk prevention is often too general and not sufficient for specific jobs. There is a lack of updating of knowledge in ORP material, both in terms of frequency (refresher or reinforcement training) and in terms of content (new trends, risks, methods, techniques, equipment, technologies, etc.). There is a need for innovation in ORP training by implementing new methodologies or training techniques and making them more practical and less theoretical.

From the worker's point of view, a lack of knowledge of prevention and ORP regulations was detected. A large number of workers do not see training in ORP as necessary for the development of the job they perform. There is a lack of awareness of motivation and participation of workers during the ORP training stage, which greatly reduces the results of the training and frustrates both roles, trainer-pupil.

Once the training deficiencies have been defined, the objectives of the training action are established as a preventive technique. The aim is to favour the internalisation of the preventive culture among workers, to promote improvements in the level of health and safety protection, to transmit competences and knowledge about specific risks and preventive measures.

To achieve social and occupational awareness among workers about the specific risks of their job. To promote the integration of prevention at all hierarchical levels of the company. Promote attitudes and transmit tools on healthy habits and physical and mental health. To comply with the legal requirements for the protection of workers by the employer. To achieve the motivation and participation of workers during the training process in order to guarantee the internalisation and interest of what is worked on in the training. Promote practical training, which is more important than the theoretical part. Ensure that workers acquire and master the content. This is achieved through a training monitoring and evaluation plan. In this way, the optimal transition to the workplace is sought, of all the knowledge learned, modifying previous contrary behaviours and optimising processes from a preventive point of view.

In the design phase of the training plan, the training programme is structured in three main blocks. In order to address the training in its entire scope, development and evolution. Within each block, a series of courses are planned that will be shown in the results. The block of common training actions will focus on the verification, identification and monitoring of the workplace and its environment. Interferences between activities, rights, obligations, road safety and first aid, as well as emergency measures. The block of specific training actions will focus on the definition of work and specific preventive techniques, auxiliary means, equipment and tools. Finally, the block of complementary training actions will define health promotion, physical and emotional well-being and psychosociology.

In terms of planning, it has been carried out in a course delivery format. With a duration of between 2-6 hours per course, which will be planned in 3 blocks. These are: induction, refresher and complementary training. The induction training will be the training received by all company employees when it is decided to implement this training plan.

Recycling training will be that which must be carried out by workers who begin to work in the welding of metal structures section. Even if they already work in the company in other departments or activities. Or the training to be carried out by all workers in this sector when it is necessary to update the contents of the training courses or to include new ones. Such as, for example, the incorporation of new technologies, new manufacturing processes and complementary training. All this will be received by all workers, regardless of their incorporation. It will be secondary to induction and refresher training, and will be the last stage of ORP training. It will have to be implemented in the medium term, but it will be compulsory.

The timing of the training plan was developed following the structure established in the previous planning, consisting of three training blocks, differentiating between common, specific and complementary training actions. These training blocks contain a total of 19 training courses. They have a minimum duration of 2 hours and a maximum duration of 6 hours. The total duration of the training plan is 46 hours distributed over 4 weeks as shown in Table 1.

Table 1. Planning the timing of the training plan

Structure of actions	Workload (hours)	Percentage distribution	Weekly occupancy (weeks)
Common formative actions	16	35%	1
Specific formative actions	18	39%	2
Complementary formative actions	12	26%	1

At an operational level, once the training plan has been implemented in the company, a programme of courses will be drawn up, with several calls for each of them (the repetitiveness and the calls for these courses will depend on the size of the company). In such a way that workers register for these courses, depending on their availability and the productive needs of the company. The recommended order in which to take the courses corresponds to the correlative numbering of the courses. However, this order can be modified depending on the availability of the workers, production and the availability of the teaching staff. The execution of the courses will be carried out in a 100% face to face mode in order to avoid the deficiencies of the online or blended system. The courses will have a combined format between theory and practice. For which a training room will be needed, as well as a welding workshop and even the participation of external companies (some of the activities will take place outside the work premises).

The registration and accreditation of the training received according to this training plan will be approached from two dimensions, on the one hand, the official accreditation through the Metal Professional Card (MPC) and, on the other hand, an internal accreditation, through a registration form and its subsequent migration to a control database.

After carrying out a study of the training needs and deficiencies in the area of ORP and after defining the objectives to be achieved through the development of this training plan. A training strategy is established which will be composed of some motivating elements through which they will try to achieve these objectives that must meet the needs.

The training strategy consists of implementing and applying different motivational elements in the development of the training plan, which will be grouped into six main strategic lines. Firstly, lectures and talks by experts, the aim of which is to arouse the interest and increase the motivation of the workers who are going to receive the training plan. Another strategic line of work coaching techniques, which aims to improve the motivation of workers, enhance their creativity, participation, improve teamwork, collaboration and improve social and emotional skills. On the other hand, the presentations of real cases, the aim of which is to raise awareness among the workers who are now students. Integrating in them the preventive culture from a point of view of experience, real events, accidents, risk situations or scenarios that have existed and which will be exposed in first person. The promotion of the practical part over the theoretical part, trying to reduce the theoretical part to a minimum. The fifth strategic line is the application of project-based learning (PBL), the aim of which is to acquire key knowledge and skills in ORP material. Through a real project that will combine different areas of the ORP material and that will have a practical application related to the work activities of the students. Finally, the implementation of new technologies and digital training resources in the training plan. Including new technologies and training resources as part of the training process, which will make the training more dynamic, strengthen and make it more efficient. Achieving an increase in student interest, awakening motivation and participation among the workers involved.

In the case of the training plan of study, different didactic methodologies have been used in combination, such as master classes. These are present in the theoretical parts of the training courses designed, and consist of the transmission of information on ORP material by the teacher to the students. The discussion groups, in this format of didactic methodology, consist of a technique of sharing opinions, solutions or points of view, focused in a didactic way. In such a way that they allow interaction and learning in a dynamic and participative way. Cooperative learning is a methodology that focuses on learning as the result of collaboration, inclusion and teamwork of a small group of students. Autonomous learning, where the student's own intervention in his or her own process is taken as the protagonist. Finally, PBL, which consists of the development of a common project. In which a group of students will develop the project in an interdisciplinary way, tackling different areas of knowledge through the project, playing an active and participative role.

## 2. Results and Discussion

After carrying out the different phases of the study described above, the results obtained are set out below, defining the development of the training plan. Table 2 and Table 3 show the training courses that make up each of the training blocks.

Table 2. Common formative activities

COURSE 1 - ACMN-1	Risks of falling heavy objects.
COURSE 1 - ACMN-2	Risks of falls at the same level.
COURSE 1 - ACMN-3	Risk of blows against objects or machine-tool elements.
COURSE 1 - ACMN-4	Risks due to entrapment by and between objects.
COURSE 1 - ACMN-5	Heat stress.

Table 3. Specific formative activities

COURSE 6 - AESP-1	Boiler and welding works.
COURSE 7 - AESP-2	Surface treatment application work.
COURSE 8 - AESP-3	Equipment and work tools.
COURSE 9 - AESP-4	Risks and preventive measures in jobs with risks of falls, entrapments or blows.
COURSE 10 - AESP-5	Risks and preventive measures in work with electrical risks.
COURSE 11 - AESP-6	Risks and preventive measures in handling chemical products, toxic fumes or explosive atmospheres from welding.
COURSE 12 - AESP-7	Risks and preventive measures in work with repetitive movements and forced postures.
COURSE 13 - AESP-8	Risks and preventive measures in work with exposure to noise, vibrations or high temperatures.
COURSE 14 - AESP-9	Risks and preventive measures in jobs with risks of cuts or projections of particles.

Table 4. Complementary formative activities

COURSE 15 - ACMP-1	Care of the back.
COURSE 16 - ACMP-2	Healthy habits.
COURSE 17 - ACMP-3	Manual handling of loads.
COURSE 18 - ACMP-4	Psycho-emotional well-being.
COURSE 19 - ACMP-5	Stress.

Table 5 shows the distribution of the different training courses designed according to reception, recycling or complementary formats.

Table 5. Distribution of training blocks

Host training														Complementary training				
COURSE 1 - ACMN-1	COURSE 2 - ACMN-2	COURSE 3 - ACMN-3	COURSE 4 - ACMN-4	COURSE 5 - ACMN-5	COURSE 6 - AESP-1	COURSE 7 - AESP-2	COURSE 8 - AESP-3	COURSE 9 - AESP-4	COURSE 10 - AESP-5	COURSE 11 - AESP-6	COURSE 12 - AESP-7	COURSE 13 - AESP-8	COURSE 14 - AESP-9	COURSE 15 - ACMP-1	COURSE 16 - ACMP-2	COURSE 17 - ACMP-3	COURSE 18 - ACMP-4	COURSE 19 - ACMP-5

Recycling training

Figure 1 shows the timing of each of the training days and courses for a full-time worker. With a standard working timetable for an employee in this sector. That is, a working day from 6:00 to 14:00.

	WEEK 1					WEEK 2					WEEK 3					WEEK 4					
	L	M	X	J	V	L	M	X	J	V	L	M	X	J	V	L	M	X	J	V	
6:00 - 7:00																					
7:00 - 8:00		C.2				C.6	C.8	C.13			C.9	C.10	C.11	C.7							
8:00 - 9:00	C.1																				
9:00 - 10:00			C.3	C.4	C.5				C.14			C.12				C.15	C.16	C.17	C.18	C.19	
10:00 - 11:00																					
11:00 - 12:00																					
12:00 - 13:00																					
13:00 - 14:00																					

Fig. 1. Proposal for the timing of the training plan

Figure 2 shows the implementation of all motivational elements in all training actions as a whole. In order to observe the distribution of these motivational elements in the different training courses.

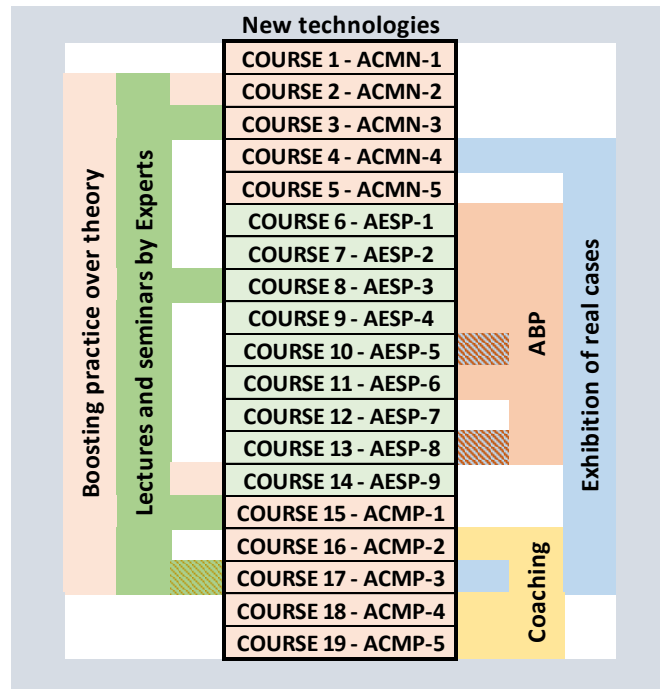


Fig. 2 Distribution of the affectation of the motivating element

To monitor the results obtained by the trainees when carrying out the training actions. Monitoring and evaluation will be carried out. The evaluation of the training plan consists of 4 levels of evaluation. The first level (monitoring) evaluates the implementation of the programme, the attendance of the trainees and the interventions of the teachers, as well as the satisfaction and impressions of both. The second level (immediate evaluation) evaluates the knowledge and competences acquired by the trainees immediately after the end of the specific training. In the case of the study training plan this will be done at the end of each training course. The third level (intermediate evaluation) assesses the real and operational effectiveness of the training, i.e., whether behavioural changes towards the prevention factor are detected after the training. This change in behaviour is called effective transfer or migration to the workplace. And it is one of the main objectives sought in ORP training. In the training plan of study, this will take place 2 weeks after the complete completion of each of the training actions. The fourth level (long-term evaluation) evaluates the final effectiveness and the real effects of the training received. This evaluation is carried out with the managers and the prevention committee. It consists of comparing data on accidents, accidents, sick leave, incapacity, morbidity, etc.

The contents of the training plan are specific to the activity related to the welding of metal structures. They include information on existing equipment, tools and technologies. However, in such a dynamic and changing society, a continuous revision and updating of the contents is necessary. With the aim of adapting and addressing comprehensive training in prevention in different scenarios. Some of them are the arrival of new equipment, tools or work technologies. The introduction or modification of the organisation of work management. The incorporation of new activities for workers who carry out their activity in welding metal structures. The modification of ORP regulations, legislative changes relating to worker training. Figure 3 shows the complete composition of one of the courses that have been elaborated and planned in this research. The description of the content, the teaching load of the training, the modality, the teaching methodology, the necessary equipment and the teaching staff can be found.

TRAINING PLAN - WELDING METALLIC STRUCTURES COMMON TRAINING ACTIONS			
COURSE NAME	COURSE 01 - RIGHTS AND OBLIGATIONS IN THE MATTER OF ORP. PREVENTIVE POLICY OF THE COMPANY. ORGANIZATIONAL STRUCTURE.		REFERENCE
WORK LOAD (Hours)	2	PROFESSORATE	Matter expert
MODALITY	Presential	METODOLOGÍA	Theoretical
NECESSARY MEANS AND EQUIPMENT	Classroom with projector, computer and sound equipment. Wi-Fi connection. Mobile availability for students.		
DESCRIPTION	For a worker to carry out their work safely, it is essential that they know the risks, rights and obligations in PRL		
CONTENTS			
Item 1	Introduction to Occupational Risk Prevention.		
	Item 1.1	Basic notions. Key concepts.	
	Item 1.2	Rights and obligations regarding PRL.	
Item 2	Generic risks in workplaces		
Item 3	Generic preventive measures.		
Item 4	Safe work procedure.		
Item 5	Actions in the event of an emergency.		
Item 6	Business hierarchy in PRL.		
Item 7	Preventive policy of the company.		
Item 8	Organizational structure.		

Fig. 3 Description and information about COURSE 01-ACMI

The results and effectiveness of a training plan depend to a large extent on its design and planning. In the primary stages, objectives can be focused and prioritised, investments can be requested, methodologies can be modified and implemented. Consequently, strategies can be managed more flexibly. However, at later stages, it becomes more difficult due to its rigidity and results are lighter. In designing this training plan, special consideration has been given to training needs. Therefore, the training objectives have been the fundamental pillar in the design and planning of the plan. This a priori allowed us to resolve and fulfil the proposed objectives. Some of the proposed objectives have been approached from various strategic lines. Reinforcing and complementing each other, to ensure their fulfilment. For example, one of the main objectives of the plan is the promotion of practical training over theoretical training. This objective has been addressed through the creation of several strategic lines. Such as project-based learning, the implementation of virtual reality through simulators or active job coaching in the factory.

### 3. Conclusions

The main shortcomings or training needs in prevention suffered by workers in this sector are the lack of motivation and participation. The training courses are very theoretical, which is perceived as tedious and useless, together with a lack of innovation and revision of training content. This leads to a lack of participation, demotivation, a perception of prevention as a mere formality and, in general, a major hindrance to the establishment of a preventive culture.

With the development of this training plan, the problems of participation and motivation are tackled at the root. Through dynamic strategies of teamwork, participatory practices, where the student learns actively. This has been achieved by implementing a training plan consisting of 18 courses, distributed in 3 blocks of training actions (common, specific and complementary) which are developed and coordinated using PBL, work coaching techniques, lectures and seminars given by experts in the field of ORP. Combining it with an evaluation made up of 4 levels, ranging from the satisfaction and opinion of the students, to the results and long-term accident rate data of the company. In this way, conclusions of effectiveness can be drawn, including the immediate evaluation 2-3 weeks after the implementation of the training plan.

The importance of training in the prevention of accidents at work and in the improvement of health and safety protection is emphasised. Quality training informs, prepares and enables staff in any sector to deal with, detect and protect themselves from risks. However, the current perception of many workers and organisations is one of contempt and bureaucracy.

Consequently, efforts and resources must be invested in developing appropriate, active and participatory training. This will enable workers to be aware of the benefits and virtues associated with occupational safety training.

As future lines in which this research can be continued, it would be the implementation of the training plan in ORP company. In this way, the results could be analysed and the plan could be improved in order to adapt it to welding tasks in metal structures on site, not just limited to a welding workshop.

#### 4. References

- [1] CNAE. (2009). Listado completo de actividades. Clasificación Nacional de Actividades Empresariales [Online]. Available: <https://www.cnae.com.es/lista-actividades.php>
- [2] Confemetal (2021). Mapa Sectorial del Metal en España. Confederación Española de Organizaciones Empresariales del Metal [Online]. Available: [https://www.fmfce.com/documentos/Observatorio%20FMF\\_2020\\_Mapa%20sectorial%20del%20metal%20en%20Espa%C3%B1a.pdf](https://www.fmfce.com/documentos/Observatorio%20FMF_2020_Mapa%20sectorial%20del%20metal%20en%20Espa%C3%B1a.pdf)
- [3] Instituto Nacional de Seguridad y Salud en el Trabajo (INSST). (2019). Informe anual de accidentes de trabajo en España [Online]. Available: <https://www.insst.es/documents/94886/785254/Informe+anual+de+accidentes+de+trabajo+en+Espa%C3%B1a+2019.pdf/550b6df1-a35c-437d-84fc-1cd679c044d7?t=1605797627935>
- [4] Boletín Oficial del Estado. (2022, Sep 8). Ley 31/1995, de 8 de noviembre, de prevención de Riesgos Laborales [Online]. Available: <https://www.boe.es/buscar/pdf/1995/BOE-A-1995-24292-consolidado.pdf>
- [5] Boletín Oficial del Estado. (2017, Jun 19). Resolución de 7 de junio de 2017, de la Dirección General de Empleo, por la que se registra y publica el II Convenio colectivo estatal de la industria, la tecnología y los servicios del sector del metal. [Online]. Available: <https://www.boe.es/buscar/doc.php?id=BOE-A-2017-7009>
- [6] Boletín Oficial del Estado. (2006, Oct 4). Resolución de 12 de septiembre de 2006, de la Dirección General de Trabajo, por la que se dispone la inscripción en el registro y publicación del Acuerdo Estatal del Sector del Metal. [Online]. Available: <https://www.boe.es/buscar/doc.php?id=BOE-A-2006-17345>
- [7] D. Cobos, and A. Garí “Formación de los trabajadores para la prevención de riesgos laborales en la empresa: Percepciones de los agentes sociales de la Comunidad de Madrid,” *Escuela Abierta.*, vol. 11, pp. 87-107, 2008.
- [8] Fundación Laboral de la construcción. (2021, May 26). Estudio sobre las necesidades formativas en el sector de la construcción [Online]. Available: <https://www.observatoriodelaconstruccion.com/informes/detalle/estudio-sobre-las-necesidades-formativas-en-el-sector-de-la-construccion>
- [9] Boletín Oficial del Estado. (2022, Jan 12). Resolución de 29 de diciembre de 2021, de la Dirección General de Trabajo, por la que se registra y publica el IV Convenio colectivo estatal de la industria, las nuevas tecnologías y los servicios del sector del metal. [Online]. Available: [https://www.boe.es/diario\\_boe/txt.php?id=BOE-A-2022-479](https://www.boe.es/diario_boe/txt.php?id=BOE-A-2022-479)