Safety guide

woodworking facilities

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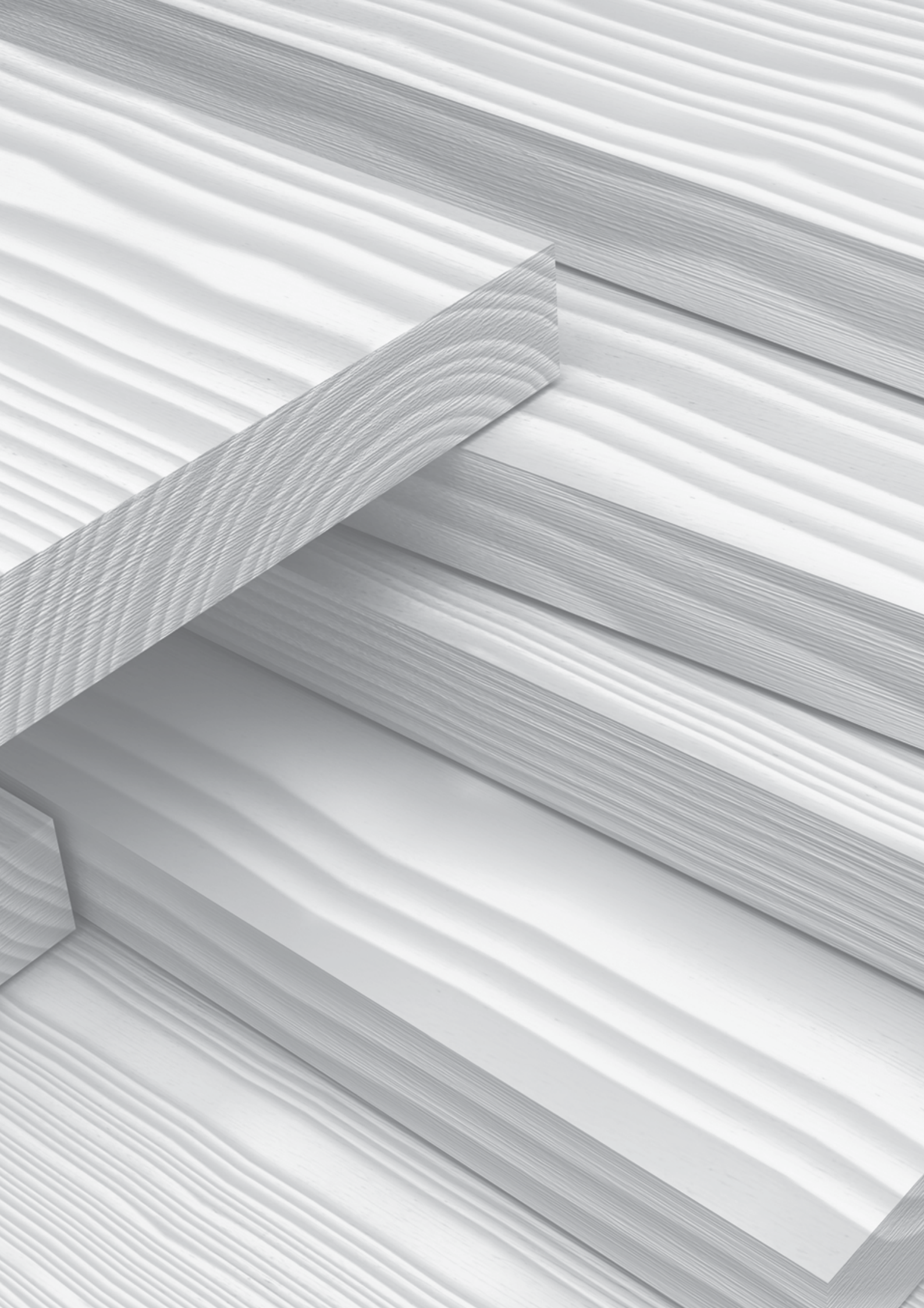

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> 01 Introduction

Due to the high fire load of wood and the presence of dust or sawdust, along with the existence of volatile organic compounds present in varnishing, painting or lacquering operations, woodworking is an industrial activity with a high risk of fire. This Guide is intended to serve as support for the businessman in this sector when it comes to identifying and analyzing the risks associated with this activity, as well as the adoption and implementation of prevention and control measures, all of this aimed at achieving reasonable safety levels for persons and properties.

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Macroeconomic sector information

The use of wood and its application as the predominant element in furniture production is one of the most antique industrial activities which has adapted through time to the market needs thanks to, among other things, the technological advances.

Wood industry produces solid wood boards and manufactured boards in lumber mills and similar places. In Chart 1 we can see world production data for industrial uses.

According to Food and Agricultural Organization for United Nations (FAO) report, demographic growing, added to Gross Domestic Production (GDP) increase in Asian, African and East Europe countries will increase world wide demand for forest products. This growth of demand will be satisfied mainly by the own local markets and importation too.

The furniture industry is a basic activity in the economy of industrialized countries, representing between 2% and 4% of the production value in the manufacturing industry, around 2% of the GDP and 2.2% of the employment generation capacity.

Most of furniture producers are small industries with less than 50 employees, but usually organized in associations that bring together common area producers. Wood and furniture production is a complex sector with a lot of subsectors and great differences between them, such as production, industry size and position in market.

The growth of the furniture industry is basically determined by the demand from the household consumption and the favourable situation in the construction sector. During the last decades, the fast evolution of the sector has been possible

thanks to the incorporation of chain production, automatization, reduction in production costs and rationalization of work.

Furniture industries were placed in Europe and North America traditionally, but the increase of labour cost in developed countries translates production to emerging countries especially in Far East.

Strategies patterns to compete against delocalization point to quality management, take care about innovation and design and add value products.

Environmental restrictions in developed world trend towards forest plantations instead of native forests as raw material source.

Also forest plantations produce positive effects for the society because it contributes to mitigate the greenhouse effect and climate change.

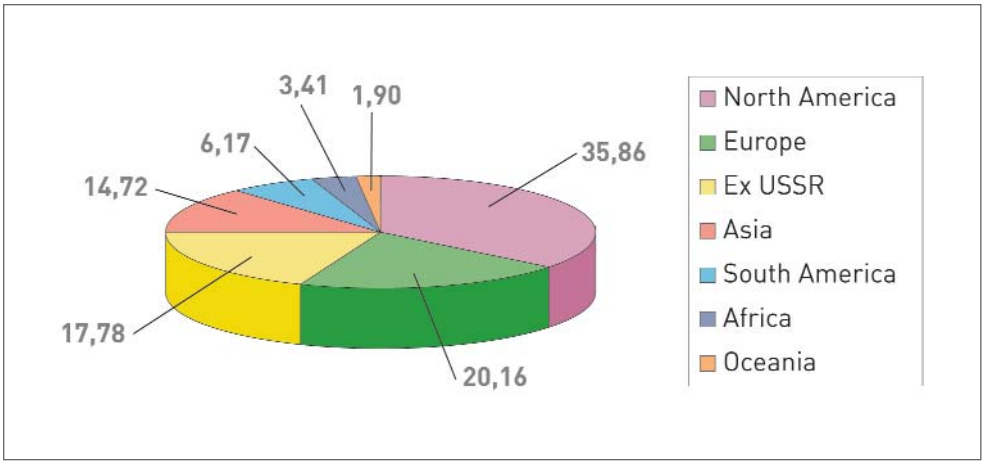

Chart 1: Wood Production estimation for 1990 (thousand of m^3), source OIT "Wood Industry" Health and Security Work Encyclopaedia.

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Raw materials and manufacturing processes

There are a large number of different processes involved in wood products manufacturing. Next, the most important aspects related to the essential raw material, i.e. wood, as well as the most frequent processes in woodworking facilities, are set out in summary.

3.1. Raw materials

Wood used as raw material in woodworking facilities can be:

- Solid wood.
- Semi-finished wood: laminated, particle, plywood, melamine or fibre boards, among others.

Solid wood

Solid wood can be classified in different ways depending on the criterion used. One of the most important criteria refers to hardness and texture properties.

- Hard woods: oak, holm oak, beech, etc.
- Soft woods: chestnut, birch, black poplar, etc.

- Fine woods: walnut, cherry, etc.
- Exotic woods: mahogany, ebony, teak, rosewood, etc.

Solid wood

Semi-finished wood

- **Laminated wood**: It is made up by low thickness sheets with diverse lengths, assembled by means of multiple joints and stuck to each other with synthetic adhesives, with the fibres in the same direction, in order to obtain solid elements of rectangular section.

Laminated wood

An important drawback for natural wood is the limitation regarding the surface of the boards, which is limited by the log diameter. In order to solve this problem, prefabricated or artificial boards are produced, generally of good quality and economical, made from wood waste or low quality woods.

- **Particle boards**: These are made from wood particles glued together (particles/glue proportion of 9:1). They offer multiple advantages: they are economical, they are not attacked by insects or wood diseases, they can be presented in large sizes, their entire surface is usable, they are easy to work with, and have medium hardness and density.
- **Plywood boards**: They are made up by thin wood plates bonded together with resistant glues (phenol or urea resins or other thermosetting resins are used nowadays). The number of plates to be bonded depends on the desired final thickness, but it must always be odd (between 3 and 19) and be laid with alternate grain direction, in order for the two exterior plates to present the same grain direction.
- **Melamine boards**: These are particle boards coated with melamine cover which is directly polymerized on the board, making it more resistant to external agents and providing an impermeable finish.
- **Fibreboards**: They are made from pressed wood fibres. This fibreboard is obtained by grinding the wood particles, resulting in small wood threads. Fibres can be bonded together with agglomerating substances like glues or resins. However, as the fibres are made up by cellulose and lignin and have self-agglomerating properties, the use of glues is not indispensable. The resulting material is uniform and allows for machining processes similar to those with solid wood (milling, carving, etc.). Their faces and edges have a perfect finish and they allow direct application of paints or varnishes. The main drawback is their high weight, but they can often be found in designs of household and office furniture of large distribution groups.

Fibreboard

With regard to their fire behaviour, it is important to remark that, despite being a combustible material, wood does not burn so easily as it might seem. Without the presence of flame, it needs a surface temperature higher than 400 ºC for its ignition. On the other hand, in the presence of flame, the surface temperature must reach about 250 ºC during some time before ignition. The more divided the wood, the higher risk of fire, as in this situation wood has a larger heat exchange surface.

The heat value (energy given off in the form of heat after ignition) of dry wood is around 19,000 KJ/kg, whereas if wood gets damp, its fire load is reduced according to the following relation:

Net Heat Value (KJ/kg) = 19,000 - 220 M

M: Moisture content as a percentage of total weight

The fire behaviour of wood gets worse when it is present in the form of particle, fibre or melamine boards, the basic element of which is wood, but which also contain other elements in their coating, combustible or flammable by themselves, such as glues, polymers or varnishes.

If these data are transferred to the most usual configuration of a woodworking facility or a wood furniture manufacturing plant, the fire load density in this type of premises ranges from 500 MJ/m^2 to 600 MJ/m^2, whereas in storage areas it can achieve 800 MJ/m^2.

Other raw materials used in woodworking facilities which must be born in mind at the time of analyzing the hazards in this type of premises are:

Chemical products storage

- Chemical products: glues, sealers, varnishes, dyes, lacquers, paints, solvents and other finishing products.
- Leather, fabric, fibres and organic foams (e.g. polyurethane), if upholstering operations are carried out.
- Packaging materials: cardboard boxes, plastic for shrink wrapping and cardboard or plastic corner units.
- Metal elements (ironwork), such as screws, hinges, locks and rivets.

3.2. Manufacturing processes

There is a great variety of manufacturing processes according to the type of wood used in the woodworking facilities and the variety of possible finishes. Following, only the most usual ones are described:

- **Raw materials reception**: Depending on the way they are managed, the entry of raw materials in the woodworking facilities may result in the presence of spots with high density of wood and, therefore, with a high fire load.

Wood storage shelves

- **Cutting and sectioning** of the board to the required dimensions, by means of circular or band saws.

  When the particle board is not veneered, this must be veneered according to the following steps:

  - Cutting of veneers (by means of guillotines).
  - Joining together of veneers (by means of a sewing machine).
  - Gluing (thermosetting adhesives of the urea-formol type) by means of roller gluing machines.
  - Pressing: Bonding together of veneer and board through application of pressure and heat.
  - Machining: Cutting, bevelling, drilling, etc.
  - Sanding.

- Piece **machining** through consecutive trimming, by means of individual or complex machines performing several operations in a continuous way:

Press

planers, thicknessers, profilers, table saws, bevellers, lathes, millers, tenoners, moulders, etc. The hazardousness of woodworking machinery is linked to the amount of sawdust and shavings produced.

Circular cutting saw

- Through **sanding** and **polishing**, the surfaces of machined pieces are prepared before being subjected to surface finishing processes. These operations are carried out in abrasive machines, mainly sanders and polishers. It is in these machines where the largest amount of fine dust is produced.

- Once achieved the surface qualities required, then comes the moment to carry out the **varnishing and**

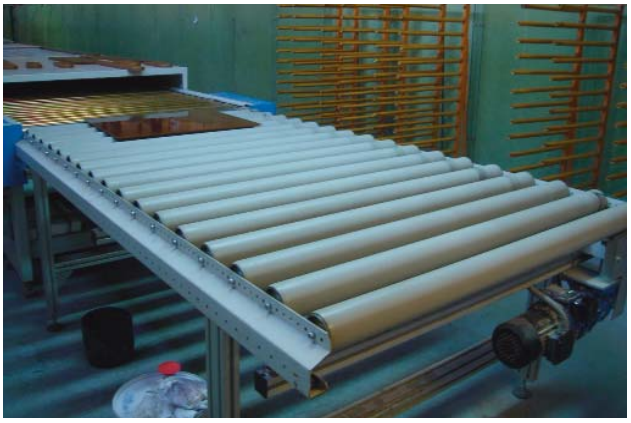
painting operations. One first layer of varnish or paint (bottom) is applied on the dry piece, then it is left to dry again and it is sanded and painted again (finishing). In any of the two cases, the spaces where they are performed must be conditioned to prevent dispersion of volatile substances.

Curtain paint inside booth

Paint booth with air extraction

Paints and varnishes are applied either inside varnishing lines for flat surfaces (the pieces undergo a series of operations like: sanding, polishing, and curtain application of putties, paints and varnishes) or gun spraying for the rest of pieces (paint booths). Intermediate drying operations are performed inside the varnishing line by means of infrared and/or ultraviolet lamps.

- **Drying**: The painted or varnished pieces undergo a drying operation in order to eliminate the remains of the solvent used in the varnishing operation or, in certain cases, for polymerization or curing of the paint applied. This operation may be carried out in drying tunnels, where the pieces, placed on carts, are carried at a certain speed according to the tunnel length and working temperature.



Varnishing rollers

Drying oven

- Once the different wood elements are finished, the last operation before shipping consists of **assembling** or joining the different items making up the piece of furniture with the addition of the prefabricated elements, ironwork, upholstering, etc. Tools and certain presses are used for gluing the pieces together.

  The final product will have to be packaged for delivery to the client. To this aim, the materials used are cardboard boxes, shrinkable plastic, etc., as well as cardboard or rigid plastic corner beads, commonly used to protect the piece of furniture during storage and transportation.

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General hazards in woodworking facilities

The very activity of a woodworking facility implies a series of hazards both for the workers and the establishment, among which the following can be outlined: fire, explosion or a possible third party liability, employees' liability and even environmental liability.

4.1. Hazards for workers

Workers in the woodworking industry may be affected by many serious hazards from the point of view of the Occupational Health and Safety. These mainly are caused by equipment and work tools, as well as other secondary elements produced during the operations usually carried out in these premises:

Cuts and entrapments by mobile objects. This type of hazard is more common when using planers, drills, circular saws or spindle moulders, among others. The prevention of this hazard requires the existence of protective defences at the handling point of saws and other cutting equipment, as well as gears, belts, chains, pinions and entrapment points of conveyors and rollers. Railings or cages should be placed next to machines near personnel traffic areas, and double operation button systems should also be set up in order to stop the machines in case of emergency.

Cut resistant protection

Blows by objects or hand tools. Blows in hands and feet due to use of hand tools are frequent in woodworking facilities and, in some cases, if proper measures are not taken, these may lead to more serious problems. Due to this, gloves must always be worn to prevent blows, pricks or contact with glues or any other hazardous product. In the case of mobile heavy equipment, it must be provided with light and acoustic warning signals. Pedestrian ways and vehicle traffic ways must be clearly signalled.

Fragment or particle spatter. In many operations, like those involving the use of circular saws, non-return devices are needed to prevent jammed wood pieces from being shot out of the machine. Glass screens or other similar safety materials should be placed between the workmen and the working points, due to the hazard of sawdust, wood chips and other waste expelled by saws causing -mainly ocular- injuries to workmen.

Safety screens

Contact and exposure to noxious substances of different nature like, for example, varnishes, glues, paints or other more hazardous substances like acids or solvents. Information is a key element to mitigate hazards, so that it is necessary to provide workers with instructions of use and actions in case of accident, as well as train them on the handling of personal protection equipment (if necessary).

Electric discharges due to contact with elements of the electrical power system, with electrical equipment, portable machines, portable lamps, etc. It is recommended in these cases that equipment should be grounded and also periodically maintained.

Muscle injuries due to poor postures or carrying heavy weight. Classification, selection and other tasks may imply the manual handling of boards and other heavy pieces. Conveyors, ergonomically designed reception boxes and appropriate material handling techniques shall be used in these cases, in order to prevent injuries in the back and upper extremities in general.

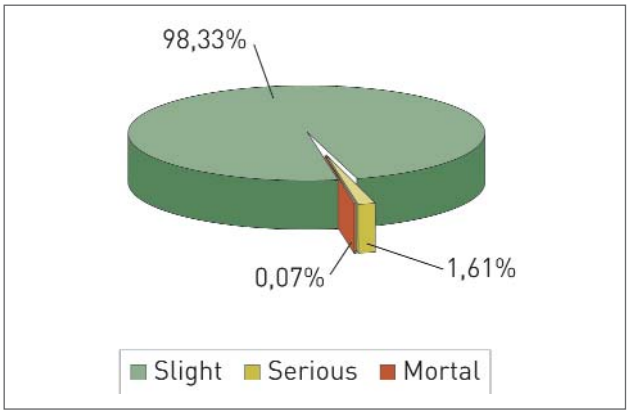

Chart 2. Types of accidents in the Woodworking Industry (Source: INE).

Intoxication due to air intake in stuffy atmospheres produced by:

- Volatile Organic Compounds (VOCs), derived from the use of varnishes, solvents, paints, thus requiring local exhaust extraction systems.

- Gases resulting from chemical reactions during battery charging.

Respiratory problems or other diseases[1] caused by inhalation of wood dust and sawdust. Another usual ailment due to working in woodworking facilities is the one resulting from the exposure to too high "noise" levels.

[1] Wood dust, the most present substance in woodworking industries, is classified by the IARC (International Agency for Research on Cancer) as a carcinogenic substance for humans -Group 1-). Very high relative risks of sinonasal cancer are observed among workers exposed to high levels of dust from hard wood, like beech, oak and mahogany.

There are viable technical solutions, such as local exhaust ventilation systems, in order to minimize the amount of contaminants in air. It is also possible to combine several measures in order to reduce noise and dust emissions. For example, enclosed booths reduce the exposure to both noise and sawdust and also prevent ocular and other kind of injuries. It is essential to control the hazardous accumulations of dust and sawdust by keeping the facilities under perfect conditions of order and cleanliness.

4.2. Hazardous fire starting points

Undoubtedly, one of the most critical aspects related to woodworking in the establishments where wood is transformed and manipulated is the **fire** hazard. It is mainly due to the coexistence of a combustible material (in a solid and pulverulent state) together with several sources of ignition, some of them permanently present. Additionally, the presence of flammable materials (varnishes, glues or solvents) facilitates the fire propagation, with the possibility of bringing about devastating consequences.

The main ignition sources are the following:

- **Electricity**: Underdimensioning and lack of maintenance in electric switchboards, low and high voltage rooms and transformers may lead to electric failures resulting in a fire.
- **Cutting and welding** operations **and hot works**, in general.
- Friction or rubbing **sparks** in machines, exhaust pipes of diesel forklifts, as well as sparks produced in sawdust, shavings and sanding dust extraction systems, caused by strange bodies.
- Inadequate **heating** devices (heaters, braziers, etc.).
- **Arson**: defined as "the crime of maliciously, voluntarily, and wilfully setting fire to property of another or of burning one's own property for an improper purpose".
- **Smokers**.

Woodworking facilities have an important density of materials -mainly wooden ones- with a **high fire load**, forming piles with a great density of ground occupation in the form of boards.

Besides wood and derivatives (particle board, plywood board, veneer, etc.), glues, paints, solvents and varnishes are also utilized in wood furniture manufacturing, together with other auxiliary products such as laminated plastics, polyurethane foams, packaging cardboard and plastic, increasing the risk of fire.

Woodworking facilities and furniture manufacturing plants are also exposed to another hazard inherent to this activity: **explosion**.

- In **paint booths**, where lacquering, enamelling and varnishing operations are carried out, explosive atmospheres are produced due to the mixture of vapour and air, as well as the dust clouds.
- **Wood dust and sawdust atmospheres**. Dust from sanding and machining of certain type of woods is susceptible to igniting very rapidly and cause an explosion. It is essential to keep the order and cleanliness to prevent hazardous accumulations and, above all, provide the equipment they are produced by with dust and sawdust **extraction systems** to transport and place them in silos located outside the industrial building. These silos must be frequently emptied in order to prevent auto-combustion[2].

Dust and sawdust accumulations

[2] Property which allows some materials producing spontaneous combustion. It is present in some substances stored when the oxidizing action of certain microorganisms produces a increase in temperature up to the ignition temperature until combustion is produced.

The **storage** density in woodworking facilities is usually high, which sometimes results in impairment of access to protection means, evacuation routes and even emergency exit doors. This circumstance aggravates the consequences of fire, so that care shall be taken to keep said zones obstacle free at any moment, posting signs if necessary.

Accidents: One third of the serious fires in furniture manufacturing plants take place in storage areas, and half of them usually happen during the nightime. Besides possible malicious acts, one of the most frequent causes for these types of fires to start is the fact that, upon occurrence of any electric failure or any other situation which may result in fire, the lack of personnel capable of mitigating these incipient fires results in fire spreading all over the premises with no resistance, which may bring about devastating consequences for the company and also for the adjoining properties.

High density of stored wood

Within the manufacturing area, most fires start in the varnishing and painting sections, especially in sawdust and shaving extraction systems, and also in auxiliary equipment and installations.

4.3. Damages caused by external agents

As it happens in other activities, woodworking facilities are exposed to external factors which may cause damage to real and personal property:

- **Flood and damages caused by water**: Water may cause serious damage either on raw material, semifinished or finished products. When in contact with water, wood (mainly in the form of particle boards and fibreboards), undergoes the swelling phenomenon, which modifies the physical and mechanical properties of wood and makes it vulnerable to biological attacks.

  Floods (usually caused by riverbank overflowing, pipe and downpipe breakage, etc.) may lead to flooding inside the buildings and besides the direct damage there are also certain occupational hazards associated, like the contact with electric wires, possible structural instability or environmental pollution due to spillage of hazardous substances to the public network, etc.

- **Theft**: Despite the fact that woodworking facilities do not present high risk of theft of final products or raw materials, they are more exposed to theft of tools, accessories and spare parts, data processing equipment and, in its case, cash.

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Hazardous situations in woodworking facilities

5.1. Hazardous operations

In order to correctly analyze the specific hazards that woodworking facilities are exposed to, it is necessary to identify which of the processes carried out inside these premises are capable of causing a possible fire to start or spread. Some of the most important processes are following described:

Paint booths

In order to minimise risks and control the explosive atmospheres surrounding surface treatments (painting, lacquering and varnishing) the application should be carried out in isolated booths. Nevertheless, these deserve special attention in relation to fire hazard due to the accumulation of a high concentration of Volatile Organic Compounds, paints, solvents, varnishes and lacquers (toxic and flammable materials). An additional hazard is the presence of boilers and compressors for regulating both the temperature inside the booth and the pressure required by the equipment, together with the previously mentioned flammable products.

In order to prevent stale atmosphere inside paint booths, they shall be provided with air extraction/exhaust systems, as well as an adequate control of filtration panels, especially in gas evacuation zones in the case of forced ventilation systems. On the other hand, in order to minimize risks in this kind of premises, it may be mandatory -in accordance with the Low Voltage Electrical Equipment Regulations to provide electrical installations with explosion-proof protections to prevent the contact of a potentially explo-

sive atmosphere with any electric element which may generate sparks (electrical contacts always produce a little spark inside of them) or accidental overheating.

Paint booth

Water curtain in paint booth

The maintenance of these paint booths must always be carried out according to the manufacturer's indications, with periodic replacement of filters and check on extraction pipes for air or water under the filters, at least on a yearly basis.

For the elimination of paint waste in suspension, a filtering operation shall be carried out by means of dry filters or water curtains, the latter being more desirable. These filters shall be cleaned without solvents, as the accumulation of these in the ducts is one of the main causes of fire in painting facilities.

Varnish and paint should be stored out of the manufacturing building, as indicated in Section 5.2.

Process equipment

The current production pace in the wood industry makes necessary, even in small woodworking facilities, the use of equipment with high electric power for operations such as cutting, pressing, forming, etc. This equipment has a high energy demand, which increases the fire hazard due to electric failure, aggravated by the wood dust or sawdust environment which usually surrounds switchboards and connections, and the high fire load (wood piles) homogeneously distributed all over the industrial building.

Assembly press

Infrared (IR) thermographies are a very useful tool for detecting anomalies in the electrical installation. This technique allows measurement of the surface temperature of different components by using a camera (thermal imager) to measure the natural emissions of infrared radiation from objects that have an increased temperature. As a result, a thermal picture can be produced to allow accurate analysis. The thermography can detect in advance, even months ahead, deficiencies in electrical installations such as connection overheatings, over or undertightening, etc., which might result in breakdowns or even fire.

As a general rule, periodic preventive maintenance of equipment shall be programmed following the manufacturer's indications, and correct handling shall at any time be assured. The equipment with remaining residual hazard shall be provided with the pertinent warning signals by means of standardized indicators.

Small handheld tools, which may seem less hazardous than large machines, may produce during the process enough heat or sparks capable of causing a fire to start.

Manual feed 2-wheeled grinder

In any case, the electrical installation shall be designed and implemented according to the Low Voltage Electrical Equipment Regulations. In the case of woodworking facilities, the Regulations distinguish, at the moment of assessing the risk and putting forward the opportune measures, different hazard levels for machining and varnishing areas, and the latter should have fire compartmentation from the rest of activities carried out on the premises. Compartmentation consists of providing the industrial premises with construction elements (walls, partitions, floorings, roofs or doors) which are able to confine the fire inside a delimited area (fire compartment) so that it is prevented from affecting the entire building.

Pile of wood close to switchboard

As for electrical transformers, besides being subject to mandatory periodic reviews, the main consideration is the fact that they shall be located in totally independent premises, either in a separate small building, inside the main building or annexed to it. In the last two cases, it shall be required a fire compartment with a fire resistance of at least 180 minutes (REI-180) (see Section 6.2).

Welding and oxycutting works

Although welding is not a usual process in woodworking facilities, maintenance works in equipment, furniture and extension works, among others, usually require this type of work. Accident facts in industrial establishments show that hazardous situations take place within the wood working process due to spatters of melted metal around the workplace, and also due to electrodes and hot tools, or by the effect of heat conduction through the metal (for example, the structure or a metal pipe), causing an important increase in temperature even at a certain distance from the welding point.

It is especially hazardous to weld or carry out hot works in the presence of:

- Combustible products at the reach of welding sparks.
- Combustible products in contact with ducts or pipes being worked on.
- Wood dust, sawdust, wood, paint and varnish waste on the floor, either at reach of sparks or in contact with hot ducts.
- Combustible construction elements, especially sandwich panels with insulating polyurethane or polystyrene, used in paint booths and closings.
- Tanks and ducts containing or having contained flammable liquids or gases.
- Ducts with combustible thermal insulators.

In order to prevent this hazard, **Performance Protocols** shall be implemented for welding works carried out by own or subcontracted personnel. Attached at the end of the present Manual there is a sample Hot Work Permit applicable to all kind of environment.

Working with batteries

In woodworking facilities with an important volume of end product it is usual to find storage at height areas, which implies the use of electric stackers and forklifts. Any battery charging has its hazards, as

hydrogen and oxygen are given off during this operation. This phenomenon takes place in the water electrolysis reaction during the final stage of charging and especially in the case of overload. Hydrogen is an extremely flammable gas, and if its concentration is within the range of inflammability or explosivity (4% to 79%) in enclosed premises, there is a risk of explosion in the presence of any ignition source. So, it shall be avoided a concentration reaching the lower explosion limit of hydrogen in air (4%), the charge shall be verified and intensity supplied by the charger shall be regulated. It is necessary to ensure that the battery charging area has enough ventilation. Moreover, this area should be provided with explosion-proof lighting, and there shall not be combustible or flammable elements, or ignition sources, in the proximities.

Battery chargers

Other hazards of this type of activity are possible burns due to electric arc and splashes of sulphuric acid (highly corrosive), being more serious in the case of explosion with breakage of the battery container.

Explosive atmospheres

When organic materials -like wood- are in dusty condition, they are susceptible to explode when there is a sufficient concentration in air (higher than 20 g/m3). Once the initial explosion has occurred, the explosion pressure may raise dust deposited on other surfaces, which may lead to secondary explosions capable of multiplying all over the premises. It must be remarked that combustible dust is an insidious hazard, because it accumulates in hidden areas and difficult access areas.

In order to prevent dust explosions once the hazard has been identified, it is recommended:

- To put into practice effective cleaning programs in order to eliminate dust accumulations.
- To control the possible ignition sources.
- All equipment producing dust, sawdust or shavings shall have local pneumatic extraction systems, provided with sleeve filters or cyclones which, by means of ducts, deposit the waste in silos located in the outside of the woodworking facility.

Sleeve filters

- The extraction system must be provided with earth connections and explosion relief systems. In the most hazardous cases, spark detectors and an automatic water extinction system within the interior of ducts are also recommended.
- There is auto-combustion hazard in sawdust and wood dust storage silos, which can be mitigated by emptying them on a weekly basis.

Sanding machine with vacuuming system

Besides dust, Volatile Organic Compounds from wood finishing processes are also susceptible of generating explosive atmospheres. For flammable vapour extraction there must be ducts installed, independent from the rest of extraction systems, which shall be periodically cleaned in order to prevent accumulations of these materials.

Compressed air

Compressed air installations present numerous applications in a woodworking facility, such as serving machine tools, drying operations, cleaning during cutting, or finishing treatments (like varnishing, lacquering or painting).

Compressed air equipment

The main hazard in this installation is the explosion of the expansion tank. Due to this, compressors are placed in independent premises, or attached to the building, one of the enclosing walls being prepared to release the pressure wave. This compartmentation shall be designed in such way that damage caused is minimal.

The proper treatment of this risk factor is completed with the performance of annual reviews as well as a pressure test every ten years.

Other hazards for workers derived from woodworking processes are:

- Hearing loss due to the high noise level generated.
- Accidental particle spatters from blowing nozzles.
- Direct exposure to the compressed air jet.

Boilers

Boilers are used for heating the water or thermal fluid used in the process and also for building heating. In this kind of premises, boilers are prepared for burning liquid (generally fuel oil) and solid (wood clippings, sawdust and shavings) combustibles

Industrial buildings are usually heated by means of air heating units through heat interchange of ambient air either with vapour or overheated water produced in the boilers or with thermal oil in some cases. In no case shall it be permitted to use heating systems by incandescence, open flame, gas heaters or electric heaters were waste and sawdust are burnt, nor the use of fluids (in case of use of air heating units) with a temperature higher than 150 ºC. If ducts do not have an appropriate thermal insulation, vapours may be given off and wood may get dried, thus increasing the likelihood of fire.

Internal transport equipment

There is a fire and explosion hazard associated with gas oil if this is used as forklift fuel. As a preventive measure, transport equipment should be equipped with a spark extinguisher in the exhaust pipe, and special care shall be taken with the location of fuel tanks.

5.2. Handling and storage of hazardous products

For the performance of storage or handling operations of hazardous products (solvents, lacquers, varnishes, etc.), work instructions shall be established to regulate aspects such as:

- Working area and activity carried out.
- Identification of the hazardous substance.
- Risks for humans and the Environment.
- Protection measures and behaviour guidelines.
- Action in case of danger and first aid to be rendered after the occurrence of an accident.
- Waste removal and disposal conditions.

Among the recommendable measures for storage of handling of flammable products, the most remarkable ones are the following:

- Mixing and decanting of flammables should be done in safety containers, taking special care in the selection of the mixing equipment, ventilation and drainage, as well as aspects related to order, cleanliness, maintenance and specific prohibitions to maintain the safety levels.

- Due to auto-combustion problems, spillages should not be neutralized with sawdust, but with inert substances like sepiolite. Due to this same reason, cloths impregnated with flammable substances shall be placed in lidded metal containers, which shall be emptied at the end of each working day.

Compartmented paint mixing

Within areas of application of varnishes, paints, etc., there shall only be the amount of hazardous products required for a day's work. Besides incombustible containers, there should be safety cabinets with automatic airtight lock to store small amounts of flammable liquids like solvents or products containing them, such as solvent cans, paints, varnishes, etc., paying special attention not to perform welding works or use open flames with ignition sources nearby.

In other hand, protection cabinets shall meet the following conditions:

- Their fire resistance shall be of at least 15 minutes.

- They shall have a clearly visible notice of "flammable".

- No more than three cabinets of this type shall be installed in the same room, unless each group of three is separated by a distance of 30 m from each other.

- In case of keeping Class A products (liquefied products having an absolute vapour pressure exceeding 1 bar at 15 °C) the cabinet shall be ventilated to the outside.

Storage rooms. Flammable products shall be stored in buildings or parts of them for storage use only, and whose structures, ceilings and walls, connected to other rooms or adjoining buildings with a 120 minute fire resistance (REI-120) (see Section 6.2). Doorways to other rooms shall feature automatic fire doors with a fire resistance of at least 60 minutes (RF-60), and the floor should have a certain slope and also be drained towards a safe place.

Storage rooms shall have a lightweight enclosure to the outside (like openings, windows or venting areas) to allow pressure relief in case of explosion, for storage of Class A liquids. The room volume shall be sufficient to prevent saturation of the stored liquids.

5.3. Environment

Among the materials usually handled in a woodworking facility, hazardous wastes are those containing some of the following substances: heavy metals, hydrocarbons, organic solvents, dust and asbestos fibres, acids and bases, and mineral or synthetic used oils, including oil-water mixtures and emulsions, which may affect the environment in different ways.

Atmospheric pollution

During the usual operations carried out in a woodworking facility, diverse polluting compounds can be emitted to the atmosphere, such as:

- Combustion gases from boilers.

- Volatile Organic Compounds (VOCs), derived from the use of solvents, varnishes and lacquers.

- Particles from cutting, planing, milling and sanding machines.

Particle extraction system

Emissions must be periodically controlled and also comply with the limits set out by the legislation in force. When the legal limits are exceeded, it is necessary to adjust the operation of equipment or search for corrective measures so that emission levels remain within the permitted values.

Water pollution

The water pollution hazard is one of the most important issues connected with the regular activities carried out in a woodworking facility.

It is important to comply with the limits set out by the corresponding legislation and to prevent the possible spilling of toxic or hazardous substances to public waterways or wastewater pipe networks:

- Cleaning waters of the facility.
- Accidental spillage of hazardous products.
- Direct spillage of toxic substances usually used on the premises.
- Mud from varnishing or lacquering booths.

In case of spillage of a hazardous liquid, it is recommended to use absorbent materials, as cleaning hazardous substance spillage with water increases the soil pollution hazard and generates a larger amount of waste water.

Soil pollution

Soil pollution is one of the overriding problems associated with industrial facilities. Besides conditioning the possible future soil use, it may lead to degradation of underground waters and mean a hazard for the health of people and living things. If the woodworking facility has no pavement or this is in poor condition, soil pollution may occur.

The main situations leading to for soil pollution are the following:

- Storage of oils or combustibles.
- Washing of tools impregnated with varnish or lacquer.
- Spillages. Should they take place, they shall be cleaned by means of specific methods and absorbent materials for each substance spilled, like extraction systems in the case of solids, or by means of inert substances -like sepiolite- in the case of liquids. Protocols and safe storage spaces should be used in order to minimize the consequences of possible spillage.

In order to prevent soil pollution, wood working activities shall be carried out within paved areas provided with means for containment and collection of potential hazardous substance spillage.

Waste generation

Waste is produced in woodworking facilities due to their activity. Inadequate segregation and storage of waste, hand over to non-authorized waste managers or release in the environment, represent a serious threat to the environment and people's health.

The main types of waste produced in a woodworking facility are the following:

- **Waste assimilable to urban**: Food scrap, bottle glasses, paper and cardboard, office material, packaging residues, non-hazardous product containers, cans; cloths and non-contaminated work clothes.
- **Inert wastes**: Wood scrap (sawdust and shaving), plastic scrap and pallets.
- **Hazardous wastes**: Cloths, clothes, containers and sawdust contaminated with hazardous products, dust from cutting and sanding operations,

glue or filler residues, oils and liquids from machinery and equipment, aerosols, fluorescents, batteries, etc.

Waste shall be managed in accordance with regulations in force, by scrupulously complying with all the requirements on handling, labelling, storage and hand over to authorized waste managers specified by said regulations. It is especially important to observe those prescriptions in the case of waste classified as hazardous, as these, as is well known, have a higher capacity of causing damage to the environment.

Recycling

As already seen, byproducts from wood working processes may cause environmental problems through air emissions, liquid effluents and solid wastes.

Wood chip piles may cause rain-induced runoff problems, as wood lixiviation[3] includes acids from resins, fatty acids and phenolic products, which are very toxic for the aquatic fauna. Lixiviation is also produced by the burial of wood residues, so that mitigation measures are required to protect underground and superficial waters.

Most of the sawdust and wood chips produced can be recycled precisely in other wood products like particle boards, wood or paper pulp. This better use is more usually made as waste disposal costs increase, as well as the vertical integration of woodworking companies. Nevertheless, other wastes like fine dust resulting from the machining of certain types of wood are not easily usable, so that it becomes necessary to search for other disposal means.

Noise generation

A great number of activities and equipment in woodworking facilities are capable of generating noise levels, thus requiring some kind of protection. Examples of these are: cutting saws, milling machines, sanding machines, dust extraction systems, etc.

With regard to the aforementioned, the company shall ensure compliance with legal noise limits established by municipal ordinances.

Hearing protection devices for equipment handling

[3] Lixiviation: Process of separating soluble from insoluble substances by dissolving the former in water or some other solvent.

> 06

Fire protection means

6.1. Active fire protection

The most predictable types of fire in a woodworking facility are: Class A, fire involving solid materials (mainly wood, sawdust, wood chips, besides accumulations of pallets, dirty cloths, cardboards, etc.) and Class B, involving liquid combustibles or liquefiable solids.

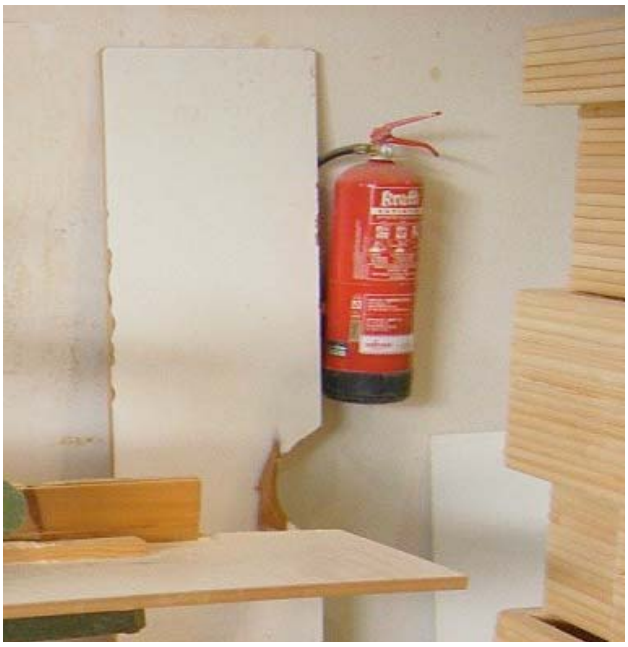
The recommendations regarding the necessary fire-fighting active protection means in a woodworking facility can be prioritized by grouping them into two different levels.

Basic level

Once the fire has started, the protection means must prevent it from spreading, even more when there is a great density of combustible or flammable material, as in the case dealt with here. The essential fire protection means are the following:

- **Fire extinguishers**. It is important to provide the building with a certain number of portable fire extinguishers for use by duly trained personnel. The fire extinguishers must have the features shown in the following table:

Type	Minimum fire rating[4]	Remarks
ABC Dry Powder	34A-144B	For use on any kind of combustible.
CO_2	89B	For use on liquid combustibles and electric equipment fire.
Water	21A – 113B	For solid combustibles. Should it contain a percentage of foaming agent, then for use on liquid combustibles.



Powder fire extinguisher to protect combustible solid

Signalled alarm button

There must be a sufficient number of ABC dry powder fire extinguishers so that the actual distance from any point to the nearest fire extinguisher does not exceed 15 m. Besides, in the proximity of electric switchboards, and in order to put out possible incipient fires in equipment with electrical components, it is recommended to install CO_2 fire extinguishers, more effective against electric fire, as polyvalent powder (with a higher extinguishing effectiveness) presents corrosion problems on this type of components and in case of discharge it might affect this equipment.

- **Detection systems and fire alarm**. An automatic fire detection system should be installed in this type of industries, mainly due to possible incipient fires which may remain latent for a certain time and develop out of working hours. These systems are especially recommended for buildings with a built area of more than 3,000 m^2.

  This detection system should be installed along with alarm buttons distributed so that the maximum travel distance from any point to an alarm button is less than 25 m. Fire detectors and alarm buttons shall be preferably connected to an external Central Alarm Receiver (CAR) capable of intervening or issuing the appropriate warnings in the event of fire.

- **45 mm diameter Fire Hose Cabinets (FHCs)**. It is recommended to install FHCs in this type of industries, and this protection mean should be installed in woodworking facilities larger than 200 m^2 located in buildings sharing other uses or attached to other buildings, and larger than 500 m^2 in isolated buildings. Besides, a private water supply system should be installed -when the public network is not reliable- for establishments where the largest fire compartment (refer to section 6.2) exceeds 500 m^2.

[4] Minimum Fire Rating: Extinguishing effectiveness against fire during a standardized test, in compliance with standard UNE 23110-1, of solid combustible, Class A, and/or liquid combustible, Class B.

FHCs should be distributed with a travel distance less than 25 m from any point. The company staff should be trained on their use.

CO_2 Fire extinguisher

45 mm Fire Hose Cabinet

- **Emergency lighting and signalling**. Evacuation routes and doors should be signalled and provided with emergency lighting.

- **Signalling of fire-fighting equipment**, so that it can be easily and quickly located.

Emergency lighting

Advisable level

In addition to the aforementioned measures, the implementation of the following is recommended in order to achieve a higher protection level:

- **Wheeled fire extinguishers**. Additionally to the number of handheld fire extinguishers installed, either one wheeled 50 Kg or two 25 Kg ABC powder fire extinguishers should be installed per 1,000 m^2 or fraction thereof of storage area.

- **Automatic fire extinguishing systems**. For the prevention of electric hazards (transformers) or in potentially explosive atmospheres like those in painting, lacquering and varnishing booths, fixed CO_2 or water mist extinguishing systems are recommended (water mist is the best extinguishing agent in fires caused by shaving and sawdust, besides being useful for fighting electric fire). Moreover, an automatic sprinkler system[5], should be installed, especially if the largest fire compartment in the building exceeds 2,000 m^2

- **Automatic fire detection and extinguishing systems**. To protect dust, shaving and sawdust extraction systems.

- **Fire hydrants**. Like in the case of sprinklers, when the largest fire compartment in the building exceeds 2,000 m^2, it is recommended to install a hydrant system capable of delivering 2,000 l/min flow rate at a 7-bar pressure.

- **Water supply for fire protection**. In general, supply from the public network is recommended. However, if it is not reliable, private utilities should

[5] The sprinkler system also fulfills the function of automatic detectors, so that it can make up for the lack of this system.

CO_2 extinguishing system in paint booth

Exterior fire hydrant

be installed in the building in order to guarantee the minimum pressure and flow rate required for the supply of fireplugs or, in its case, the exterior hydrant or automatic sprinkler network.

- **Emergency plan**. In order to guarantee people's safety in case of emergency (fire, sanitary emergency or evacuation) it is mandatory to have a **Self-protection Plan**. This document includes, among others, the actions to be carried out in case of emergency, as well as the assignation of responsibilities and tasks necessary to that aim. The implementation of this plan implies carrying out training courses, fire extinguishing practices and periodic fire drills for staff training.

6.2. Passive fire protection

It is usual to find small woodworking facilities located in urban nuclei sharing a building, generally in the ground floors, with other industrial or commercial establishments, or even residential buildings. In this sense, it is also essential to assess the civil liability resulting from possible damage to third parties.

Paying attention to third party liability, it is necessary that the premises make up a fire compartment independent from the rest of establishments or residential buildings. To that aim, the structural elements shall resist the effects of a fire during a determined period of time:

Building location	Structure stability under fire
Building exclusively for wood working use	Minimum stability: 90 minutes (EI-90)
Building for shared use	Minimum stability: 90 minutes (EI-90) The maximum stability shall be established according to the different building uses.

The fire safety measures applicable to woodworking facilities are usually included in the **Fire Safety Regulations**. In these types of Regulations, it is established that the distance to be kept by buildings located within urban areas with respect to others, which shall depend on the intrinsic hazard of the industry, should be: 10 m for high hazard, 5 m for medium hazard and at least 3 m for low intrinsic hazard.

In general terms, special hazard areas should be compartmented:

- With regard to enclosing walls, false ceilings and paint booths containing some **plastic insulator**, mainly polyurethane or polystyrene, compartmentation shall be secured and, if possible, these shall be replaced with other non combustible insulating minerals like rockwool or fibreglass.

- In general, the fire resistance of **doors** shall be at least half of the fire resistance of the fire compartment they are part of.

- **Storage** shall be independent from the manufacturing area (REI-180) and, additionally, different storage shall be done for: raw material (wood and the like), veneer, upholstering material, chemical products, ironwork and packagings. Out of all of them, the most critical one is the storage of flammable products, which shall be located in an independent room and, if possible, in a separate building with an explosion-proof electrical installation and adequate ventilation. They shall be separated by walls with a fire resistance of at least REI-180 (REI-240 for warehouse compartmenting walls).

Flammables storage area

- **Paint storage and decanting** areas shall be provided with safety low voltage equipment (in compliance with the Low Voltage Electrical Regulations), natural or forced ventilation and drainages. Moreover, paint and solvent decanting shall be performed in safety containers.

- With regard to the possible explosive character of some sections in a woodworking facility, it shall be taken into account that dust atmospheres or hazardous vapours shall be provided with **ATEX** protections, that is to say, apparatuses and protection systems approved for use in potentially explosive atmospheres.

Explosion-proof luminaire

- As for the fire resistance of compartments where flammable materials are applied, the following is recommended:

Zone	Fire resistance
Cleaning with solvents	FR-90
Paint application	FR-90
Paint preparation	FR-120

- Contact glues (solvent based neoprene) shall not be used in **gluing** operations, as they are very combustible, and if hot presses (T=150 ºC) are used, the giving off of carbon monoxide (CO) must be foreseen, as it is toxic and flammable.

- For **utility rooms**, such as compressed air, heating, boilers, main electric switchboard, transformers, power generator, pumps rooms, etc., REI-90 is recommended.

- In **sales and office areas**, REI-90 is recommended if they exceed 250 m^2 each.

- Construction openings for **service ducts** (water, heating, air, electricity, etc.) going through walls or floorings making up fire compartments, shall be duly sealed with resistant materials so that the desired compartmentation is not compromised through these openings.

6.3. Other protections

Given the diversity of ignition sources and the great amount of flammable and combustible material present in woodworking facilities, it is essential to keep a scrupulous order and an adequate cleanliness and maintenance. To this aim, the following principles of good practice are recommended:

- Avoidance of overload in storage areas and an adequate waste and rubbish management.

- An appropriate maintenance program performance on machines and working equipment.

Ground painted passages between roller conveyors

The following shall be done to make fire protection systems more effective:

- Stairs and personnel transit areas shall be kept clean, obstacle free and duly signposted.

- Fire extinguishers, hoses and fire fighting equipment in general shall not be blocked.

All the employees must be informed about the fire and/or explosion hazards inherent to the manufacturing process and receive instructions regarding their performance in the event of fire.

A permanent surveillance system shall be needed according to the dimensions of the premises and the

Hazardous storage of combustible material

value concentration, making periodic rounds following predetermined routes and controlling that it is carried out by means of clock-in points. A presence detection system should also be installed, connected to an alarm centre and an acoustic-optical siren as a deterrent measure against **theft** or **intrusion**.

As seen throughout this manual, electric fire hazard, flammable and toxic materials, as well as manual operations involving risks for workers' health, are usually found in woodworking facilities. All of them shall be signalled with the relevant **danger warning signs**.

It is also recommendable to **signpost** the **process equipment** hazards together with the passive protection elements, or the necessary protections on carrying out a hazardous operation for the worker's health.

With regard to **theft** prevention measures, these shall be assessed according to the degree of attraction of the properties and very significantly their easiness of transportation. From the analysis of these factors and the theft loss report, it is deduced that this factor is not critical from the point of view of the products involved in the process (raw materials or end product), this mainly affecting the theft of tools, hardware or cash.

In the case of cash, an appropriate measure is to keep it in a safe, which can also be used to safe-

guard documents of special importance and file backups.

The access to the interior of the buildings shall be protected in the first instance by resistant elements like window bars and automatic electronic control against intrusion. The alarm devices shall be connected with the central alarm in the premises and an external central managed by an accredited security company. Both centrals should be connected by means of a supervised 2-way (mobile and fixed) phone communication system or anti-sabotage devices.

In general terms, **protection against theft** is based upon the control of three complementary factors:

Physical security	• Fences • Bars • Doors • Security glazing • Etc.
Electronic security	• Alarm devices
Organization security	• Security personnel • Custody of keys • Security key control

> 07 Conclusions

Woodworking facilities, and by extension, furniture manufacturing plants have different features which, as a whole, represent a high number of hazards, so that it is convenient to implement efficient and adequate measures for each type of hazard.

Type of hazard	Impact in woodworking acilities	Protective means
Fire	• High accumulation of fire load (wood) • Explosive atmospheres due to wood dust or flammable vapours • Diversity of ignition sources (machinery, electricity, furnaces, etc.)	• Fire extinguishers • Fire Hose Cabinets • Fire detection • Fire compartmentation (manufacturing and storage areas) And at a superior level: • Wheeled fire extinguishers • Fire hydrants • Fixed extinguishing systems • Sprinklers • Fire compartmentation of areas with special hazard (technical rooms, varnishing section, etc.)

Type of hazard	Impact in woodworking acilities	Protective means
Theft	• Cash, documents, hand tools and data processing equipment	• Safes • Volumetric detectors, magnetic contacts, anti-intrusion barriers connected to the alarm centre • Communications supervised systems and anti-sabotage systems
Other material damages	• Meteorological phenomena: damages caused by water (river bank overflowing, downpipe blockage), lightning, wind, hard rain, snow, hail	• Maintenance of downpipes, drainage and rainwater pipe systems in good condition. • Lightning rod installation in high lightning rate areas
Civil liability	• Fires affecting third parties • Explosions affecting third parties • Environmental • Occupational accident	• Effective fire compartmentation to prevent damaging effects on third parties • Own active and passive fire protection measures • Recycling, waste management and spill control • Safe storage of hazardous products
Occupational hazards	• Cuts, entrapment and blows by mobile equipment • Particle spatter and contact with harmful substances • Electric discharges • Respiratory and hearing problems	• Development of Occupational Risk Prevention • Protections and cages • Personal Protection Equipments (PPEs) • Warning signals • Safety screens • Instructions of use • Correct maintenance of equipment • Work in closed booths • Local air extraction systems

Appendix

HOT WORK PERMIT (1)

CODE: INTERNAL CONTROL:	PERMIT VALIDITY (DATE/TIME): FROM: _ _ / _ _ / _ _ _ _ _ _ : _ _ TO: _ _ / _ _ / _ _ _ _ _ _ : _ _

TO BE COMPLETED BEFORE WORK COMMENCES

1. PERSON REQUESTING THE WORK

Description of work:

Location:

Expected date: _ _ / _ _ / _ _ _ _

Person requesting the work:
.....

Signature:

Position in the company: .....
Date: _ _ / _ _ / _ _ _ _

2. PERSON RESPONSIBLE FOR AUTHORIZING THE WORK

a) Shall ensure compliance with contractual guarantees (in the case of subcontracted companies) and internal safety regulations.
b) Shall authorize execution of the work only if the minimum safety precautions are observed. (COMPLETE CHECKLIST).

WHO WILL PERFORM THE WORK?	YES	NO
Own staff:	☐	☐
Subcontracted staff:	☐	☐

Company (in the case of subcontracted staff):
.....

Person authorizing the work:
.....

Having completed the corresponding safety condition checks, I hereby AUTHORIZE execution of the work for the period of validity specified above.

Signature:

Position in the company: .....

Date: _ _ / _ _ / _ _ _ _

3. PERSON PERFORMING THE WORK

a) Shall have the authorization signed by the Person Responsible for Authorizing the Work before work commences.
b) Shall stop performing the work if the safety conditions change, immediately notifying the Person Responsible for Authorizing the Work.
c) Shall comply with internal and external safety regulations, in addition to any additional instructions issued.
d) Shall verify that the minimum safety precautions are observed (SEE CHECKLIST).

Person performing the work:.....

Signature:

Position in the company: .....

Date: _ _ / _ _ / _ _ _ _

BEFORE WORK COMMENCES, CHECK THAT ALL THE CHECKLIST SAFETY CONDITIONS ARE COMPLIED WITH!

TO BE COMPLETED AFTER THE WORK HAS BEEN CARRIED OUT

4. FINAL CHECKING

The working area and any adjacent areas which may have been affected by sparks, flames or heat transfer (including upper or lower floors and the opposite side of the wall to where the work was performed) have been inspected at least once in the hour following completion of the work, verifying that no latent fires are present.

Date and time the final check was completed: .....

Person performing work:	Person authorizing the work: .....
Signature:	Signature: .....
Position in the company:	Position in the company: .....

DELIVER COPY TO: The PERSON REQUESTING THE WORK, the PERSON PERFORMING WORK and the PERSON AUTHORIZING THE WORK

(1) "Hot work" refers to all operations generating heat, sparks, flames or high temperatures, whether near or far from flammable or combustible dust, liquids or gases, or containers which contain or have contained such products. Operations of this type include, for example, soldering, oxycutting, grinding, drilling, and so on.

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CHECKLIST

(TO BE COMPLETED BY THE PERSON RESPONSIBLE FOR AUTHORIZING THE WORK)

BEFORE WORK COMMENCES	YES	N/A[1]	COMMENTS
1. Ensure that the work area has been cleared and is free of all flammable or combustible materials within a radius of at least 10 m.			
2. Ensure that there are no combustible or flammable materials in areas below the work area.			
3. Ensure that all combustible or flammable materials that cannot be removed have been protected against flames, heat and sparks.			
4. Ensure that openings in walls and floors and/or the area located below the work area are protected against flames, heat and sparks. 5. Ensure that manual fire extinguishers (and fire hose cabinets, if present) are adequate, in good working condition, visible and accessible from the work area.			
6. Ensure that the equipment used to perform the work is safe and has been checked and found to be in good working condition.			
7. Ensure that the necessary collective and personal protective equipment is available.			
8. Ensure that any possible explosive atmospheres caused by flammable vapours, gases or combustible dust have been eliminated.			

Date: ..... **Time:** .....

[1] N/A: Not applicable

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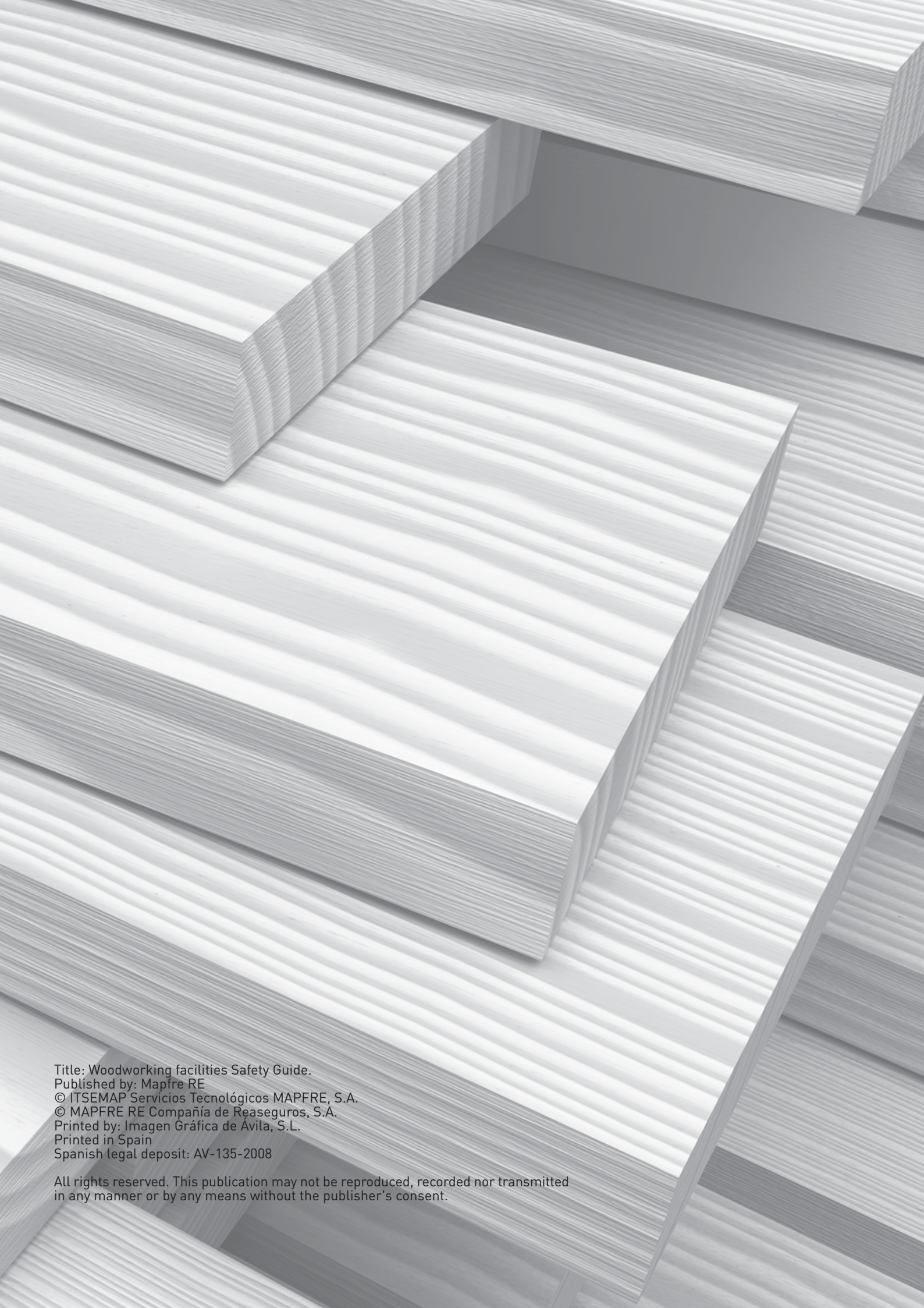

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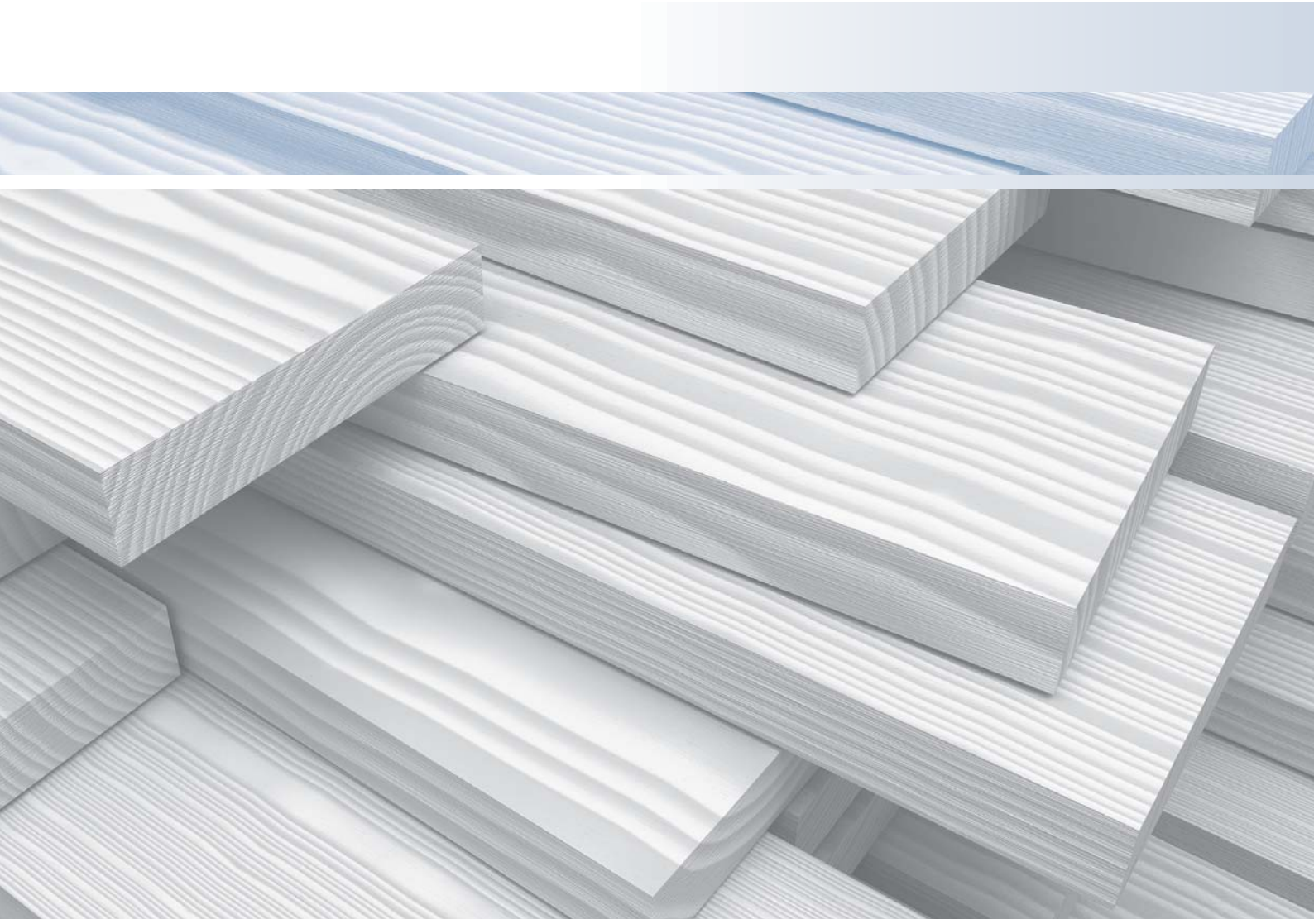

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