Safety guide

graphic-arts printing presses and workshops

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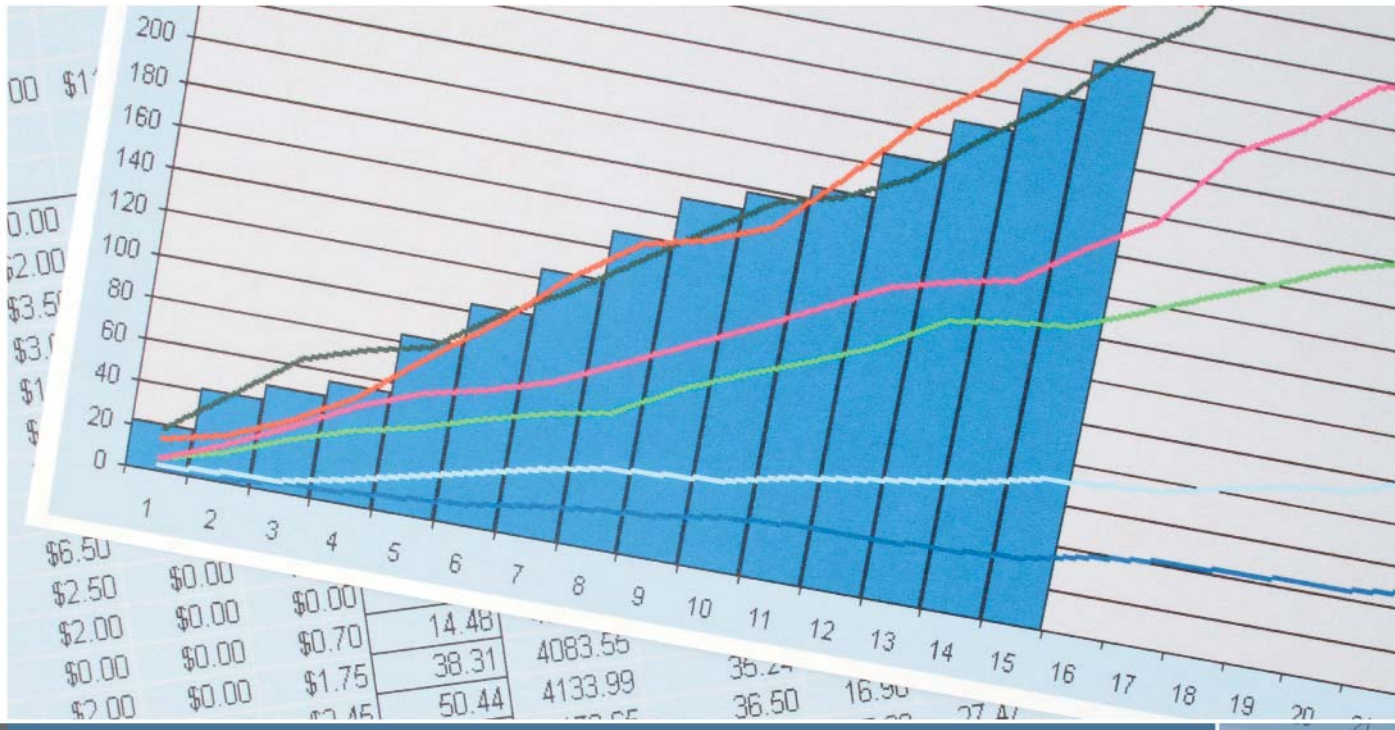
> 01 Introduction

The high fire load represented by paper, as well as its presence in the form of cuttings and dust, and also inks, alcohol, and solvents in the production processes all generate a high fire risk in the industrial activities of graphic-arts printing presses and workshops. This Guide aims to help business people in this sector with the task of identifying and analysing the risks associated with the activity and setting up prevention and protection measures in order to achieve reasonable safety levels for people and property.



> 02

Macroeconomic sector information

Printing was invented in China in the 11th century. At the end of the 15th century, Johannes Gutenberg designed movable types and the printing press, and thus developed a printing technology that is now in use throughout the world. Since then, graphic arts have experienced spectacular growth and have gone from simple text printing on paper, to text and other original artwork on paper and other materials.

In the present day, the graphic process is linked with new trends in the printing market, particularly in the customisation of marketing, which brings added value to graphic products.

PRIMIR (The Print Industries Market Information and Research Organization) is the premier market research association of the graphic communications industry and it was established in 2005 by the merger of GAMIS (Graphic Arts Marketing Information Service) and the NPES Market Committee (*National Printing Equipment Association*).

Both PRIMIR and NPES completed the study "World Wide Market for Print", which values a 18.2 % increase of the global market for print by the year 2011, to reach US$ 721 billion. Among the groups of the market, packaging and labels will be the fastest growing area with sales ahead near 20%, followed by advertising and then business and transactional printing.

There is certain concern that imports from offshore agents might grow much more than the print demand in both North America and Western Europe. In mature national print markets, such as US, Japan, Germany, UK, France, Canada and Spain, there will be a limited growth of demand, while in emerging national markets for print, with important social and demographic changes, annual growth of the demand is forecast to exceed 10%. (See chart 1.)

A big influence on the demand for print, such as publications, packaging, advertising material or transactional print, is given by the consumer together with the regional demographic and social patterns, for example those relative to working and use of leisure time.

The printing industry has historically been a labour-intensive industry, with a strong relation between the trend in turn over and employment. Machinery design, digitalization and computerisation, etc. have contributed to improving productivity very significantly and transforming this industry so that growth capacity is no longer linked to direct employment.

In the next years, an important development of social and demographic trends is expected, including:

- Increase of affluence
- Increasing literacy levels
- Steadily aging populations
- Smaller households

Globally compelling factors for the future growth of these markets are the trend towards much shorter run lengths and ability of digital printers to give solutions for new needs of consumers. By 2011, the share of the market held by the printing processes is expected to rise a 21%.

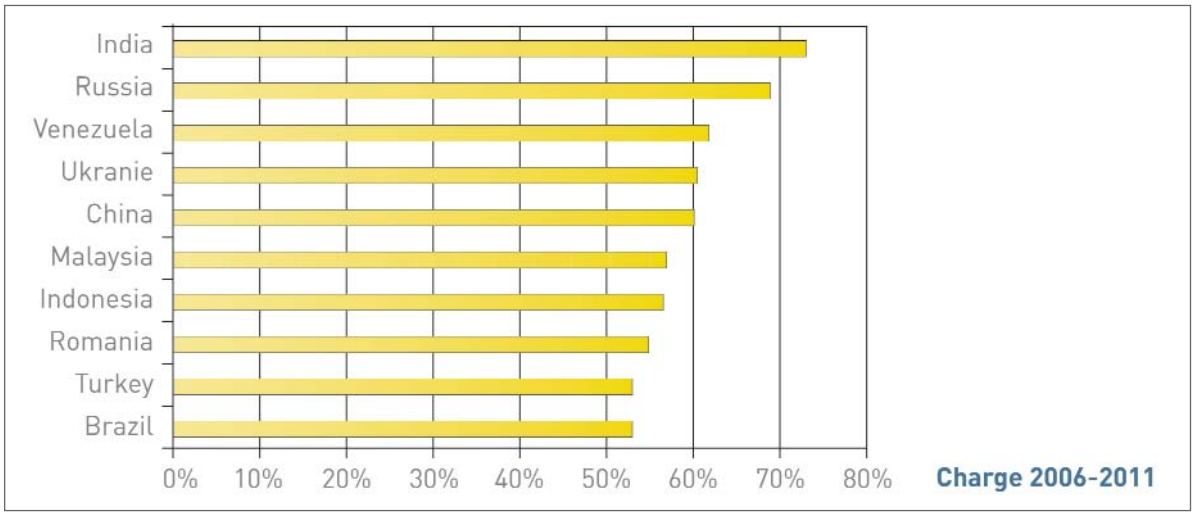
Different environmental requirements, with important cost implications, will put printers in developed regions at competitive disadvantage compared to those in emerging countries.

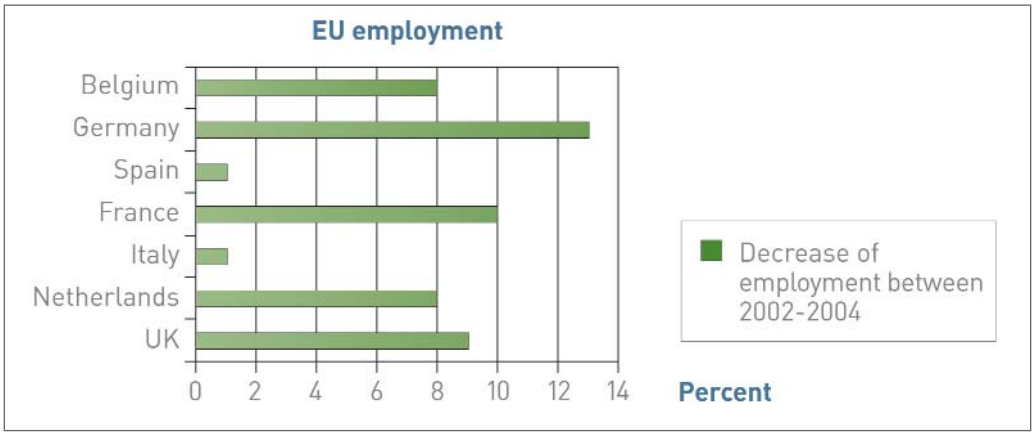
There are some guidelines recommended for printers in developed countries:

- Diversify the offers, in order to give global solutions for all the clients needs.
- Move the production or merge with production facilities in emerging countries to take advantage of lower labour costs and serve the local demand.
- Investigate in digital impression.

In short, an important evolution of the industry is expected, in which competence of diverse media, especially electronics, will grow, and additional services that aren't related directly with graphic arts, will be more important, while market groups as packaging and label will increase in importance and digital impression will grow in relation with other printing processes.

Chart 1: Print market growth in developing countries for 2006-2011, source PRIMIR "World Wide Market for Print" 2007.





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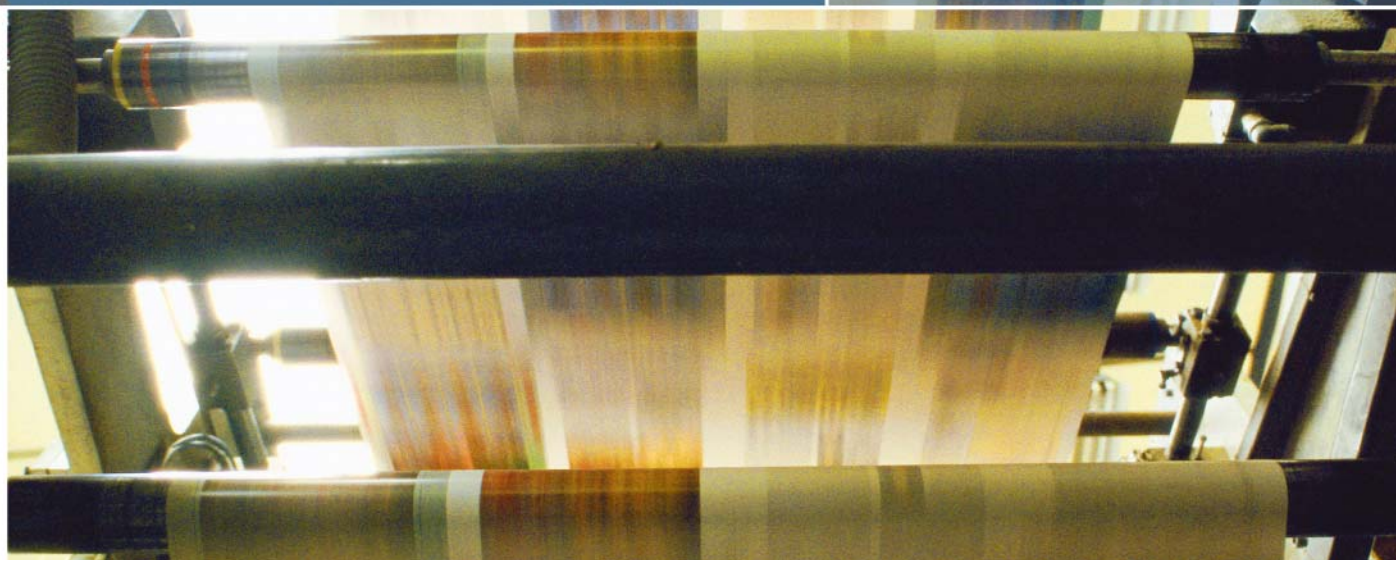
Production processes in graphic-arts printing presses and workshops



The main activity carried out in graphic-arts printing presses and workshops is printing. This can be defined as the art of reproducing any type of text or illustration in order to create many copies. The production process carried out in this type of industrial establishment is as follows:

- Raw materials storage.
- Pre-press.
- Ink preparation.
- Printing by means of various technologies.
- Finishing.
- Packaging and dispatch.

The basic elements of a printing machine are:

- Mould and corresponding medium.
- Ink reservoir and inking system.
- Paper-feeding device.
- Pressing device for applying the paper against the mould.

3.1. Raw material storage

Raw materials used in graphic-arts printing presses or workshops include paper reels or fan-fold paper, inks, printing materials, and chemical products. Paper reel storage (table 1) is classified according to the roll stacking method (vertical or horizontal).

Furthermore, the paper rolls can be identified according to the protection preventing them from becoming frayed (or unrolling). As such, they are classified as:

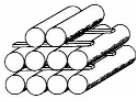
- Strapped reels, which are provided with one or more steel rings or strips at both ends.
- Wrapped reels, which are completely covered (side and bottom) with high-weight paper.
- Encapsulated reels, which are coated with shrink-wrap plastic.

Paper-reels store room

Vertical stacking of paper reels

Strapped reels with steel rings

Table 1: Paper-reel stacking methods

Stacking	Distribution	
Vertical	**Compact**: A minimum of four rows in both directions of the stack (wide and long), so that the maximum distance between contiguous reels of the same diameter is less than 100 mm. **Open**: As above, except that the distance separating adjacent reels is greater than 100 mm. **Standard**: In this method, the separation distance between rows is greater than 100 mm but within these, the reels are in contact with each other.	
Horizontal	**Pyramid**. The reels, in contact with each other, are arranged so that the ones on the upper level are resting in the spaces left by the reels on the lower level.	
	Prism. The reels are placed on spacer planks or strips between the levels.	
	Hangers. The reels are placed on metal frames acting as shafts.	

3.2. Pre-press

This phase includes the photomechanical printing (printing procedure obtained from negatives of photographic images) performed in the dark room. In photomechanical printing, photolithographs are used, which are positive films that initiate the offset printing process and act as a replacement for the negative.

In short, photomechanical printing is the process of separating the four basic colours (cyan, magenta, yellow, and black), with each one having a percentage. This process obtains four positives, a different one for each colour, and a colour proof that will subsequently be used in the printing process.

The colour proofs are printing simulations obtained from the photolithographs. This type of proof is very accurate and reliable, as it is derived from the same photolithographs that are subsequently used in the printing press.

There is now a more modern technology called CTP (*Computer To Plate*), which circumvents the need to obtain photolithographs, thus enormously improving the production process, as printing error corrections can be made directly on the computer.

Plate obtained using CTP technology

3.3. Ink preparation

The ink composition depends on the printing technology. The inks are normally composed of a carrier (alcohols, esters, ketones, or water), pigments, and dyes, and resins that will form the image. The pigments provide the colour, and are prepared using very diverse chemical products, including heavy metals and organic compounds. Isopropyl alcohol is used to increase the surface tension of the water in order to increase printing quality. The products are mixed by means of mixer tanks with blades.

Prepared ink storage room

Ink reservoirs

3.4. Printing technologies

3.4.1. Typographical or relief printing

This technology is based on producing images, generally letters or figures, elevated in relation to a background or non-printing area. The ink is applied to the elevated parts, which are then brought into contact with the paper or medium receiving the image. There are several ways of creating the relief image, such as letter-by-letter composition using movable type (linotype), or with text formed by mechanical procedures. These technologies are suitable for simple and quick printing jobs. The inks commonly used in these methods are water-based or solvent-based. New inks that dry by means of ultraviolet (UV) light curing or with the use of other physico-chemical agents are being researched and applied.

Machines that use this technology are called "platen presses", which print sheets of paper by means of two flat elements (the platen, where the mould goes, and the bed, where the sheet to be printed is placed) which press against each other.

Other machines used are die-cutting presses, which cut, emboss, and score by means of two flat elements, the platen and the bed, by exerting pressure on the working material. The material worked by the die-cutting machines is paper, card, rubber, plastic, and other similar materials. The cutter is fitted to the platen and the material to be cut is placed on the bed.

Flexographic printing

Printing with flexible plates and fluid inks that dry by means of evaporation is called flexography. This is a direct system, as the flexographic plate, once inked, transfers the ink straight to the medium. Therefore, when looking at this plate, the image text reads backwards so that the printed medium is read correctly.

The plates have a relief area that prints directly onto the substrate with light pressure known as "kiss pressure". Unlike the heavy metal plates used in the offset printing system, flexographic plates are adaptable and portable. The risk of fire in flexographic rotary presses is somewhat less, due to the low working speed.

Many pocket books are printed using the flexographic procedure. This printing system is widely used in packaging, particularly tetrapacks.

3.4.2. Rotogravure

In rotogravure technologies, the image is cut into the surface of an engraved plate or cylinder. The plate is bathed in ink and the excess is removed with a blade. It is then brought into contact with the paper or medium in question in order to transfer the image. This technology is suitable for publications requiring long print runs, such as newspapers and packaging materials. Solvent-based inks are usually used for this purpose, most commonly toluene, which is a highly flammable product (flashpoint 4 ºC), and the vapour/air mixtures are explosive.

There are two types of rotogravure: sheet or reel. The former is used for books and high-quality photographs, while the reel type is used for long magazine or catalogue print runs.

Chalcography is derived from rotogravure. This process is used for printing by means of chalcography presses with copper or zinc plates. The printing forms may be manual (wood engraving) or achieved by means of chemical incisions (etching, aquatint).

Chalcographic forms may be:

- Flat: These are obtained by manual or chemical engraving, and are used in chalcographic printing with thick oily inks.

- Cylindrical: These are cylinders with a copper electrolytic layer engraved using the rotogravure procedures.

3.4.3. Planographic or lithographic (offset) printing

The offset system is based on the indirect printing procedure whereby the paper is run through an intermediate rubber roller. The offset is based on the physical principle of water-oil repulsion (immiscibility), hence the use of oil-based and water-based inks in this method. The printing elements accept oily ink and reject water, and the blank spaces reject the ink and accept the water.

The offset system is the most widely used system in graphic-arts workshops because of the combination of good quality and savings.

Offset printing consists of the following types:

- *Offset typography*: With typographic mould
- *Offset lithography*: With a lithographic mould
- *Offset rotogravure (or offset chalcography)*: With a rotogravure mould

Printing machines with the offset system may use one or more colours. This printing system can be used with paper sheets or reels, in the latter case being fitted with a cutter and folder.

Depending on specific production needs, the offset run can be combined with other graphic-arts methods. Planographic or lithographic printing tends to use solvent-based inks (i.e. not water-based), although solvent-free preparations are rapidly becoming more common.

Offset machine

3.4.4. Screen printing

Screen printing makes use of a text image mounted on a fine-mesh screen. The ink is applied to the open areas of the screen and is pressed with a scraper on the open parts and the stencilling. The ink thus passes through the open parts and is applied to the medium beneath the mesh. Screen printing is very often used in simple jobs and short print runs, such as printing on fabrics, posters, presentation materials, and wallpaper. Screen printing uses solvent- or water-based inks, the choice depends on the printed medium. As the screen-print covering is usually thicker than normal, the inks are also more viscous than in other printing technologies.

This printing technology is widely used in advertising. It may take one of two forms according to the printing surface: flat or cylindrical. The flat type prints a range of sizes from small formats to advertising panels, posters, etc. The cylindrical type is used for decorating packs, bottles, etc.

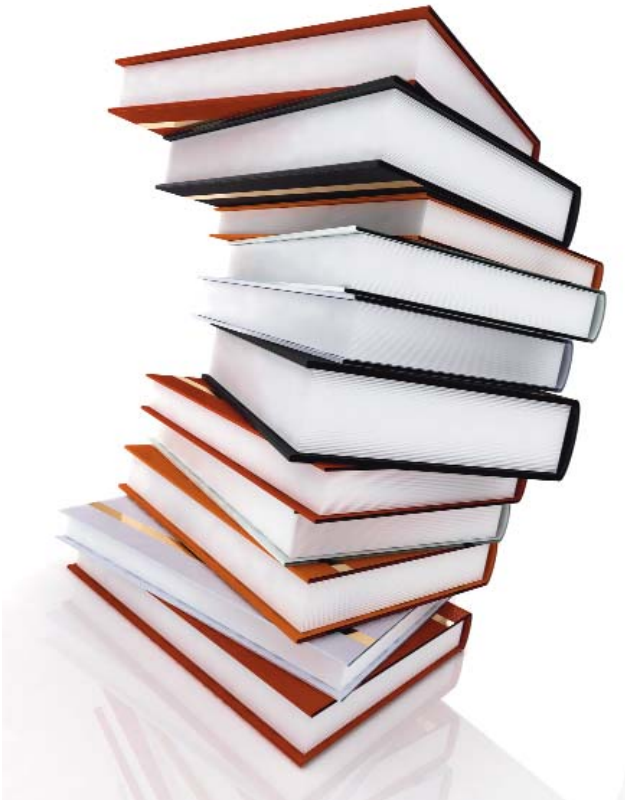
3.5. Finishing processes

The following operations are carried out as part of the finishing process:

- Pick-up of printed paper
- Cutting and guillotining
- Folding
- Stapling
- Binding

3.6. Packaging and dispatch

Final products from the graphic-arts printing presses and workshops are very variable with regard to type and format, and can be classified as follows: publications (e.g. books, magazines, newspapers), advertising (e.g. labels, posters, catalogues), and sundries (e.g. calendars, stamps, tickets, business cards). Once the work is complete, the finished products are taken to the dispatch area where orders are prepared.



Books

Stamps

> 04

General risks in graphic-arts printing presses and workshops

The actual activity in graphic-arts printing presses and workshops brings a number of risks both to workers and the establishment itself, notably fire, explosion, and any civil-liability claims resulting from accidental spillage.

4.1. Risks to workers

- **Hand and finger cuts and amputations** caused by cutting machines. The guillotines are intended to cut stacked sheets of paper. There are two types of guillotine: conventional guillotines have a single blade and make straight cuts, while trilateral guillotines can cut on the three sides of the leaflet or book simultaneously. It is important to store and operate the blades so as to prevent cuts and lacerations due to negligence. Furthermore, it is advisable to fit the machines with safety devices: hand-guard (moves the operator's body away when the blade falls), dual actuator buttons, and photo-electric cells (prevents assistant from accessing the cutting area).

- **Cuts** caused by blades used in the ink mixing equipment. The mixing blades and mechanisms must be protected during the preparation and cleaning phases. The machines must be fitted with protection devices mounted in the appropriate place.

Paper guillotine fitted with photoelectric cells as a safety measure

- **Ergonomic stress** due to manual cutting, classification, and packaging work that cannot be automated. Rotating tasks can partially alleviate this problem.

- **Trapping in cylinder assemblies or rollers**, both during normal operation and in maintenance and cleaning operations. A suitable measure would be to fit transparent retractable housing or metal grilles to prevent access to the cylinders during normal operation. This housing must be fitted with trip devices that shut down the machine if the protective housing is opened, while allowing pulse operation in order to facilitate cleaning.

- **Impacts and/or trapping by the printed paper pick-up and extraction systems**. This accident is caused by the sample-taking operation intended to verify correct finishing of the printing and to correct poorly stacked (or transported) sheets. This must be prevented by installing a transparent plastic screen and a grille preventing manual access to the printed-paper conveyance elements. This protection will be complemented by the installation of meters leading to automatic shutdown of the machine in case the screen is lifted.

- **Trapping in platen press and die-cutting machine**. The severity of the expected consequences include impact, crushing, and amputation depending on whether the trapping occurs between the bed and platen or between the bed and mould or die-cutter. The safety devices for these machines include the following:

  - Handguard devices, the protective function of which is based on expelling the operator's hands from the operating area when the bed closes against the plate.

  - Safety strip, located at the front of the machine, which shuts down the machine if the operator comes too close to the operating area.

  - Automatic feed devices, which keep the operator's hands away from the danger area.

4.2. Fire risk points

A summary is provided below regarding the fire risk points (Table 2) according to the processes and sections of a graphic-arts printing press or workshop. In section 5, Specific Risks, more detailed information is provided and preventive fire-safety measures are proposed. Other risk points in the graphic-arts printing press or workshop are as follow:

- **Auxiliary technical facilities**. These facilities help to ensure smooth production operations. Representative examples include the boiler room and the compressor room, which may be origin points for a fire and/or explosion on the industrial site. The compressed-air facilities are used in graphic-arts workshops in operations such as paper absorption, sheet stretching, and drying operations. The main risk of such equipment is explosion of the expansion tank in the compressed-air facility. For this reason, the compressors are located in a separate enclosure or an outbuilding with one of its partitions prepared to release the pressure wave. This compartmentalisation will be designed to keep damage to a minimum.

  Compulsory annual checks and a pressure test every ten years are carried out in order to ensure that this risk factor is properly managed.

  Other risks to workers derived from these types of facilities include:

  - Loss of hearing caused by the high level of generated noise.

  - Accidental particle projections from blast nozzles.

  - Direct exposure to compressed-air blast.

Compressor room

Wall-mounted unit heater

The boiler room is another technical auxiliary facility, which is generally used to produce steam or superheated water needed for dryers, heating, etc. prepared to burn liquid fuels (generally diesel oil).

The basic risk in boilers is explosion, due to the fact that they operate under high temperature and pressure conditions. Boilers must be located in a separate room or enclosure, separated from other areas (e.g production and storage). Furthermore, said area must be provided with a roof built with light materials (such as fibre cement or similar) which would act to attenuate explosions, that is, through which the energy of an explosion would be released.

Flammable products may not be stored in the boiler room. The only fuel store that may be accepted in the boiler room is the supply tank feeding the boiler. It is essential to carry out maintenance operations and check for leaks or spills underneath the supply tank or burner, as such leaks and spills combined with a source of ignition may lead to a fire.

Unit heaters are usually used to heat different sections by exchanging ambient air heat with the steam or superheated water produced in the boilers or, in some cases, thermal oil.

- **Batteries**. Charging batteries for forklift trucks emits hydrogen. This gas is explosive in concentrations of more than 4%, which is why the battery-charging area must be sufficiently ventilated to prevent overheating of the batteries and chargers, and to keep the hydrogen concentration under the

Table 2: Fire risk points in a graphic-arts printing press or workshop

Process	Sections	Risks
Storage	• Paper • Inks	Presence of combustible materials
Pre-press / mould preparation	• Typesetting • Layout • Engraving	Melting of metal letterpress moulds (high temperature)
Ink preparation		Presence of flammable liquids (inks and solvents)
Printing		Presence of combustible materials (paper), flammable liquids, and dust (paper and starch)
Finishing	• Cutting, folding, stapling, stitching • Binding	Presence of combustible materials
Packaging and dispatch		Presence of combustible materials and powdery solids
Waste collection and removal		Presence of combustible materials

Battery charging with combustible materials (printed paper) nearby

explosive limit. Furthermore, the sulphuric-acid vapour concentration must be below the established environmental daily-exposure limit (1 mg/m^3). In order to prevent or reduce these risks, the battery-charging areas must not be located underground and must be kept away from storage areas where combustible materials are accumulated. Other risk types related to batteries include burns from electric-arc discharge and sulphuric-acid splashing. Recommended applicable measures include acid-resistant waterproof flooring and an appropriate slope so that wash water and any acid spillages can run off.

- **The electrical installation** is one of the most significant factors in starting and propagating a fire. Preventive measures include: implementing appropriate and well-maintained electrical protection devices, not storing combustible material near the electrical switchboards, installing flameproof materials where necessary, installing earth systems, and carrying out thermography for preventive maintenance. **Thermography** is a technology that uses a camera sensitive to the range of values of the electromagnetic spectrum corresponding to infrared, to measure the surface temperature of different elements. Thermographic inspection therefore helps early detection, even months before, of defective aspects of the electrical installation such as overheating or loose connections, which may lead to faults or even fire.

- **Diesel forklift trucks** can also act as a source of ignition. It is therefore advisable to fit them with an arc extinguishing device in the exhaust pipe (a simple metal grille in the end section of the pipe will be enough to prevent arcs from escaping). It should also be noted that diesel oil tanks used for fuelling forklift trucks represent an explosion or fire risk. Preventive measures for diesel oil tanks include: avoiding storage of combustible materials nearby and locating the tanks outside the building.

Diesel oil supply tank with spill basin

- **Cutting and welding work**. Even though welding is not a common process in graphic-arts workshop or printing presses, this type of work is often necessary for maintenance on machinery and for expansion work among other things. Claim records at industrial sites indicate that such jobs create risk situations due to the projection of molten metal around the workplace, resulting from the hot electrodes and tools or the effect of heat conduction through metal (structural elements, metal pipes, etc.) even if not close to the welding point.

  It is especially dangerous to weld or carry out hot work in the presence of:

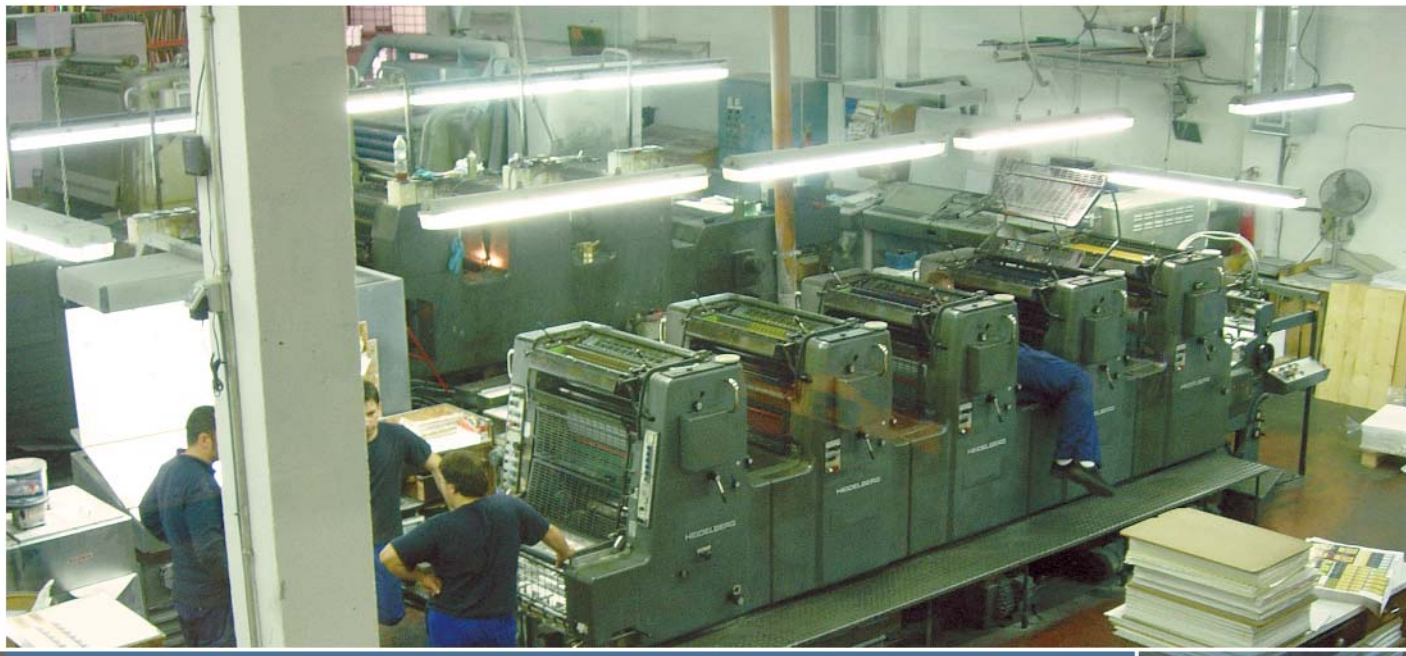
  - Combustible products located within reach of welding sparks.
  - Combustible products in contact with the conduits or pipes being worked on.
  - Paper sheets or cuttings, and paint within reach of the sparks or in contact with hot conduits.
  - Combustible construction elements, particularly sandwich-type panels with polyurethane or polystyrene insulation used in partitions.
  - Conduits with combustible heat insulation materials.

In order to prevent such work from creating sources of ignition, **Action Protocols** must be implemented for welding work carried out by the company's own or subcontracted personnel. The appendix at the end of this manual includes a Hot-Work Permit template.

4.3. Water damage

In graphic-arts printing presses and workshops, there are also external factors that may cause damage both to the premises themselves and to the goods therein. Measures are therefore required to minimise the consequences of a possible loss.

- **Water and flood damage**: These can cause considerable damage both to printing machines and to stored raw materials and finished products (books, magazines, labels, stamps, newspapers, etc.). It is important for stored goods to be kept on pallets or shelves (at least 10 cm high) and not placed directly on the floor, thus reducing any damage that may be caused by rain, spillage from conduits, etc. Protection measures against floods include proper maintenance of downpipes, drains, and fluid and/or rain conduits to ensure that these channels are not broken or crushed. It is also necessary to take into account the consequences of flooding in the industrial site and the subsequent clean-up work, as such consequences include certain work-related risks, such as contact with high-voltage cables, possible structural instability, or pollution of the environment due to spillage of hazardous substances into the public network.



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Risks specific to graphic-arts printing presses and workshops

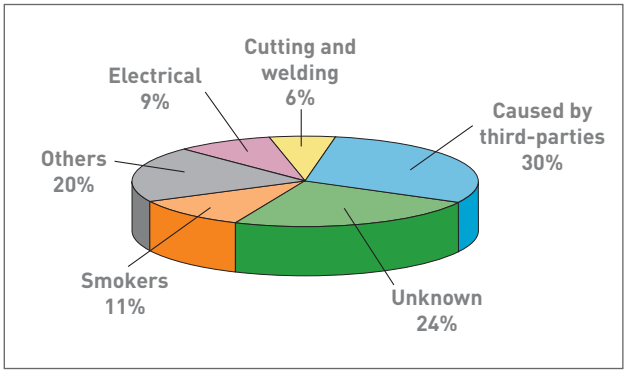
5.1. Fire risk

5.1.1. Paper storage

It is important to note that compact reels and reams (packs of 500 sheets) of paper are difficult to ignite (being comparable to solid wood). The packaging material, however, is easy to set alight. If a fire occurs, the high fire load of the paper (10,000 MJ/m3) can lead to the collapse of the building structure. As a result, if a metal structure is used, it must be protected by intumescent paint, sprayed with mortar, or fitted with plates to prevent loss of stability from fire or heating.

The main causes of fire in paper-reel store rooms (chart 3) are: fires caused by third parties, negligence by smokers, electrical, and to a lesser extent fires caused by battery charging for forklift trucks, sparks from machinery, and lightning strikes.

Chart 3: Causes of fire in paper-reel store rooms



The factors that can influence the progress and severity of a fire in a paper storage area are as follows:

- **Storage height**. The higher the items are stored, the greater the damage caused by the fire and the water used to extinguish it. An appropriate preventive measure would be to store items while observing a minimum distance of one metre to the light fittings of the premises.

- **Storage type**. In the event of fire, the reels may become frayed, which contributes to the spread of the fire. Another negative factor becomes relevant when items are not stored uniformly, as spaces between stored items promote air circulation and heat radiation between stacks. Recommended measures include metal strapping of the reels and wrapping them in high-weight paper to delay the progress of the fire.

  In the case of both vertical and horizontal stacking, the reels must never be stored up to the wall, as this arrangement of items creates inaccessible areas enormously complicating the manual struggle against fires.

- **Paper weighting**. Combustion of low-weight paper, such as tissue paper (toilet paper, napkins, etc.) greatly facilitates the start and subsequent progress of fire, which is why the expected damage is much greater than in the case of high and medium-weight paper.

5.1.2. Handling and storage of hazardous products

In order to carry out storage and handling operations for hazardous products (inks, solvents, etc.), working instructions must be established regulating aspects such as:

- Work area and activity carried out
- Identification of the hazardous substance
- Human and environmental risks
- Action and first-aid in the case of accident
- Waste removal and management

The following recommended measures are worth noting for storage and handling of flammable materials:

- Decanting and mixing of flammable materials must be done in safe containers, taking special care to choose the correct mixing, ventilation, and drainage equipment, and also the aspects related to the tidiness, cleanliness, maintenance, and specific prohibitions for maintaining safety levels.

- In light of problems of self-combustion, spillages must not be neutralised with sawdust but rather with inert substances such as sepiolite. For the same reason, cloths soaked in flammable substances must be put away in metal containers with lids, to be emptied at the end of the day.

The **ink-mixing and solvent/ink-recovery rooms** should consist of enclosures partitioned off from the rest of the industrial site. Access to these rooms must be restricted and appropriately labelled with pictograms of the associated hazards. They must also be provided with forced ventilation and a flame-proof electrical installation.

Atmospheric humidity and conductivity have a direct effect on static electricity. Therefore, in conditions of low humidity, the materials dry out and become good insulators (in which static-electricity charges accumulate), whereas if humidity is high, the materials in question achieve a humidity balance with the environment, promoting conductivity and preventing the accumulation of static electricity. Both in the ink-mixing room and in the solvent/ink-recovery room, electrical charges may be generated when running solvents through plastic hoses or in contact with air. In closed rooms subject to the risk of static electricity, relative humidity should be between 50 and 70%.

Ink dryers are the primary cause of fires in graphic-arts printing presses and workshops. There are many types of dryers: linear direct-flame dryers, hot-air/direct-flame combination dryers, gas-burner radiation dryers, electrical dryers, hot-air dryers, hot-air and steam-cylinder combination dryers, and so on. As a safety measure, the ink dryers must be provided with an automatic shut-off device that activates itself when the machine stops, and also manually-operated or automatic CO_2 extinguisher systems.

Storage rooms. Flammable-product (e.g. alcohols and solvents) storage rooms must be buildings, or part thereof, exclusively dedicated to storage and whose structures, roofs, and walls connected to other adjacent sections or buildings have a fire-resistance grading of 120 minutes (REI-120) (See section 7.2). Access to other sections must consist of automatic fire-proof doors with at least fire-resistance grading REI-60, and it is recommended that the floor have a slight slope draining to a safe area. The storage rooms shall also be provided with light partitio-

Alcohol tank

ning to the exterior (e.g. openings, windows, and venting areas) to enable venting in the event of explosion.

When handling and storing hazardous substances, it is essential for the electrical installation to be provided with increased security and good ventilation. In the presence of flammable products, such as solvents or alcohols, the electrical installation must be flameproof.

5.1.3. Production processes

- The **rotary reel machines** are used for long newspaper print runs. Fire risk is considerable due to the accumulation of large amounts of ink and paper cuttings, as well as the formation of suspended ink mist adhering to the walls and ceiling of the premises.

- During **binding**, dust gradually accumulates on the machinery, structural elements, and air ducts. It should be noted that starch dust is combustible, with a considerable fire load up to 2,000 MJ/m^2. The risk is increased by the use of combustible glues and paper dryers.

- The **cutting and guillotining operations** produce large amounts of paper cuttings and waste, as well as considerable accumulation of paper dust. An appropriate measure would be to install cutting suction systems which separate the waste by means of a cyclone action depositing the paper cuttings in a silo outside the production section.

- Explosions may occur in the **printing room**, especially in the presses that use inks with a low flashpoint. The hot air from the dryers is frequently recirculated, leading to solvent vapour concentrations in the dryers and their auxiliary conduits exceeding the lower explosive limit. After ignition, the resulting explosion may trigger another more violent dust explosion in the accumulations of starch (used to prevent printed sheets from coming into contact with each other) and of paper dust on the machinery.

5.1.4. Third-party fire damage

In the event that the industrial site partially occupies a building or is adjacent to or near other buildings used for industrial or other purposes, said buildings may be affected by a fire started in the graphic-arts workshop. This manual therefore presents recommendations aimed at the safety of the actual occupants and protection against third-party damage.

5.2. Environment

5.2.1. Waste management

Graphic-arts printing presses and workshops generate waste that has to be managed in compliance with legal requirements regarding waste handling and management, as improper separation and storage may create a serious threat to the environment and personal health.

The **main waste** generated on this type of site are:

- **Municipal solid waste**: Food waste, bottle glass, paper and cardboard, plastic, office materials, packaging waste, non-hazardous product containers, tins, etc.
- **Inert industrial waste**: Cables, wooden pallets, aluminium sheets, photo negatives, etc.
- **Hazardous waste**: Used oil, alcohols, fluorescent materials, photographic developing chemicals, contaminated containers (e.g. inks and solvents), aerosols, toner waste, contaminated absorbent materials (used to contain spillages), cloths soaked with solvents and inks, and so on.

Isopropyl alcohol is highly flammable and an irritant

Waste paper compacter

5.2.2. Water pollution

Some **spillages** may cause pollution of water, such as:

- Water with oil and grease waste
- Water from parts and tools cleaning
- Accidental spillage of hazardous substances
- Wash water resulting from cleaning the remains of polluting substances on the floor

5.2.3. Soil pollution

The main **activities** that may lead to soil contamination are:

- Changing oil or replacing parts on unpaved ground
- Storing oils, inks , or alcohols in non-watertight tanks
- Storing metal waste (scrap) soaked with lubricants and oils, and located in areas not having the necessary characteristics to prevent pollution (coating, paving, waterproofing, containment systems, etc.).

5.2.4 Controlling pollution

In order to prevent water pollution, it is essential to comply with the limits set out by the corresponding dumping authorisation and prevent any spillage of

toxic or hazardous substances that may reach vulnerable areas such as unpaved soil, sewage pipes, or sanitation networks.

Preventive and protective measures for preventing soil pollution must include paved areas and means for containing and collecting any spillages of hazardous substances.

Furthermore, it is recommended to carry out emission checks on volatile organic compounds (VOCs) when solvents are used in cleaning operations.

Hazardous substances such as oils, solvents, or alcohols must be provided with safety basins to control any leaks from tanks. It would be an appropriate measure to clearly indicate and mark off the storage area for hazardous products and waste.

Generated waste must be managed by a management entity authorised to recycle said waste. The waste may not remain on the industrial site for more than six months.

Absorbent material for containing spillages

Collection point for used ink containers

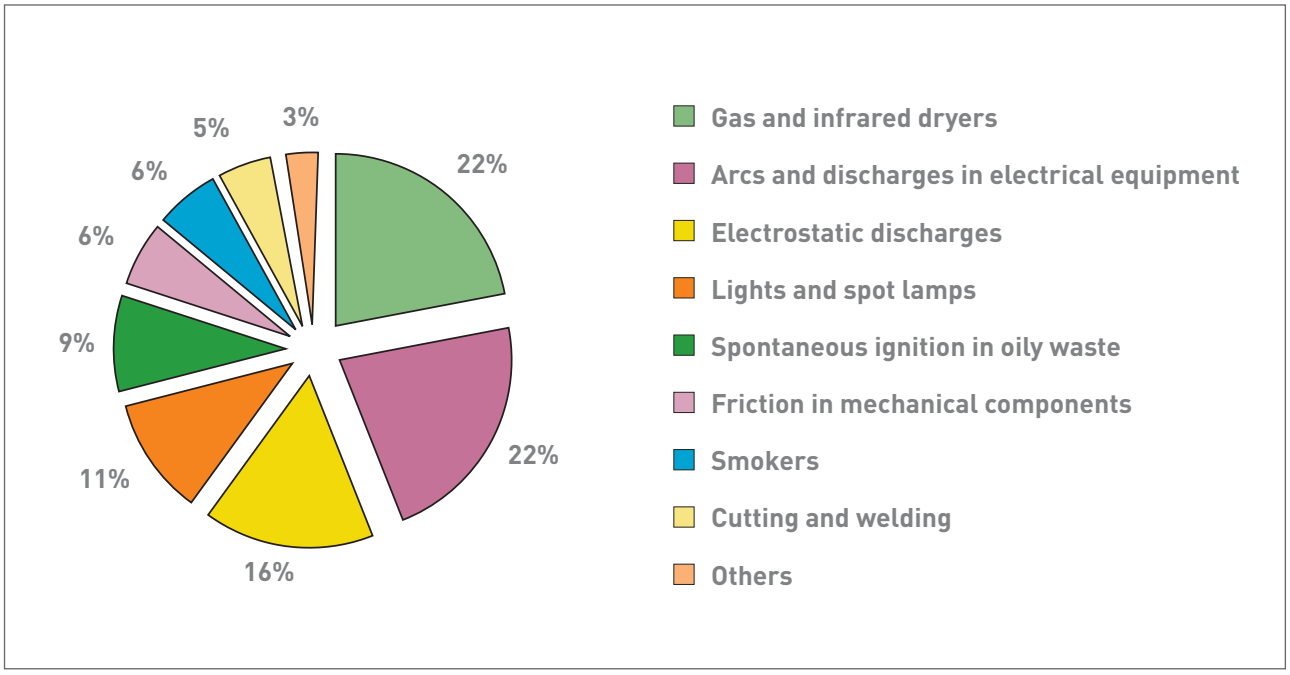
> 06

Loss histories

The following conclusions were obtained from a study on losses in graphic-arts workshops (Chart 4):

- Fires are caused both when the printing machine is in operation and when it is undergoing cleaning operations and the machine has been shut down.
- The main deficiencies are: machine not cleaned sufficiently, lack of locking mechanisms for ink dryers, and defective electrical and mechanical maintenance.
- Fires in rotogravure rotary machines were caused by ignition of flammable solvent vapours, short-circuits, or electrostatic discharges.

Chart 4: Sources of ignition in graphic-arts workshops



> 07

Protective measures

7.1. Active fire protection

The most frequent type of fire in graphic-arts printing presses and workshops is derived from solid combustible materials (**class A fires**), such as paper, cardboard, wooden pallets, dirty cloths, and plastic. There are also combustible liquids used in the production processes that can cause fires (**class B fires**), such as inks, alcohols, oils, and solvents.

The most frequent sources of ignition on this type of site and which can trigger outbreaks of fire are mainly the dryers and elements linked to the electrical installation, e.g. sparks (electrostatic discharges, electric arcs, or light fittings.

In light of the combined presence of combustible materials and sources of ignition, preventive measures must also include a set of control and fire-extinguishing means (active protection). The recommendations for fire protection can be prioritised into two different levels.

7.1.1. Basic level

Once a fire starts, the extinguisher devices must stop it from propagating, especially if the factory contains a large density of combustible or flammable materials, as in the case in question. The protective measures that we deem essential are:

Table 3: Characteristics of handheld extinguishers

Type	Minimum efficacy[1]	Observations
Multi-purpose dry chemical ABC	34A-144B	For use with any kind of combustible material.
CO_2	89B	For use with combustible liquids and electrical fires.
Water	21A – 113B	For combustible solids and, if it contains a percentage of foam, combustible liquids.

- **Extinguishers**. It is important to fit the building out with a provision of handheld extinguishers for use by people properly trained for this purpose (Table 3).

  There must be enough ABC multi-purpose dry chemical extinguishers so that the actual distance to be covered between any occupiable point and an extinguisher is no more than 15 m. Furthermore, CO_2 extinguishers shall be fitted near electrical switchboards and to attack fires in machinery with electronic components, as they are more effective in fighting electrical fires, and the multi-purpose powder (which has a larger extinguisher capacity) is corrosive and may affect installations not involved in the outbreak but which are touched by the cloud of dust generated when the device is discharged.

- **Fire detection and alarm systems**. It is recommended to install these systems on industrial sites in case of outbreaks of fire that may develop at any time when the premises are not occupied. It is particularly advisable to install them when the built area is greater than 3,000 m^2. Smoke detectors and fire alarm push buttons will be installed, and the latter shall be located so that the maximum distance to be covered is no more than 25 m. The detection centre must be located in a place supervised 24 hours a day with a connection to an external communication centre (ECC), which is able to intervene or issue the proper notices and deploy visible and audible sirens covering the entire area and ensuring evacuation of all occupants.

- **Fire-hose cabinets**. It is recommended to install 45-mm fire-hose cabinets. All areas must be located at a distance of less than 25 m from a fire-hose cabinet. It is important that company personnel be trained to use them.

45 mm fire-hose cabinet

- **Emergency lighting and signage**. The evacuation routes shall be provided with emergency lighting and markings so that all occupants can evacuate safely.

Examples of emergency markings

- **Signage for fire equipment**, which facilitates and expedites extinguishing.

[1] Fire extinguishing capacity during a test standardised in accordance with UNE 23110-1, on type A combustible solids and/or type B combustible liquids.

7.1.2. Recommended level

The following are also indicated as recommended measures to improve the protection level in the graphic-arts printing press or workshop in the event of fire:

- **Fire-extinguishing carts**. In addition to the hand-held extinguishers, every 1,000 m^2 of surface area should be provided with a **50 kg ABC-powder cart or two of 25 kg**, located by the main entrance of the enclosure, the main site entrance door, or if there are various sets of stairs, by the most central entrance door.

- **Automatic CO_2 fire-extinguishing systems** for protection from electrical fire risks, such as: electric generator room (if there is one), low-voltage room, processing centre, etc.

- **Fixed foam extinguisher system with total coverage of flammable stores**. Foams are especially useful for fighting fires from combustibles in liquid phase. Applying foam to a flammable liquid prevents oxygen from reaching its surface, thus helping to extinguish the fire.

- **Hydrants**. It is recommended to set up a network of hydrants if the site surface area is greater than 2,000 m^2.

- **Automatic water sprinklers**. As with the hydrant network, if the largest fire sector is greater than 2,000 m^2, it is recommended to install an automatic water-sprinkler extinguishing system, especially in paper storage areas, given the high thermal load.

- **Supply of water for use against fires**. It is recommended to have a reliable supply of water for use against fires. If it is not possible to guarantee a sufficient supply from the public system, a private supply must be used to ensure pressure and flow rate to the fire-hose cabinets or, if applicable, the external hydrant or automatic sprinkler network.

- **Self-protection plan**. It is important to draw up a self-protection plan in order to guarantee personal safety in cases of emergency (e.g. fire, bomb threat, health emergency, or evacuation). This document includes the actions to be carried out in the event of emergency, allocation of self-protection equipment, and drawings with the distribution of available protection means. The self-protection plan shall be properly implemented by developing training courses, establishing extinguishing practices, and carrying out regular drills (simulated triggering of emergencies) in order to train personnel.

7.2. Passive fire protection

In addition to the fire control and extinguishing systems (active protection), it is important that this activity be provided with physical elements (e.g. walls, doors, and floor structures) that limit or hinder the progress of the fire (passive protection). This protection philosophy consists of establishing a surface area or part thereof, during the design phase, in which the fire can spread to its maximum extent without affecting all the other areas. At the same time, it must be ensured that the structure supporting the building guarantees a minimum fire resistance (time in which it maintains its load-bearing capacity), so that its occupants can be evacuated and fire fighters can intervene.

Graphic-arts printing presses or workshops may be located in buildings with other uses (e.g. industrial or residential) or even adjacent to one or more other buildings. From this point of view, the graphic-arts printing press or workshop should constitute a separate fire sector, and therefore its structural parts must be designed so that if a fire is started within said sector, it cannot propagate to the bordering establishments. Furthermore, the structure supporting these premises must be fire stable for at least ninety minutes. In the case of buildings shared with other uses, minimum stability may be greater if so required by regulations for the other activities carried out in the building (industrial or residential).

In relation to sectorisation or compartmentalisation, it is recommended that all premises where hazardous activities are carried out or where there is a considerable fire load be constituted as fire sectors, capable of resisting and confining the fire, and preventing it from spreading to adjacent sectors or areas. Such premises include the following:

- **Flammable-product stores** (alcohols, machine-cleaning solvents, etc.). REI-180 grading is recommended for such cases, that is, 180 minutes of structural stability, sealed against smoke, and with heat insulation.

Compartmentalisation with EI doors in flammable-materials stores

- **Paper storage** (printed and/or reels). REI-180 is recommended.
- **General facility enclosures**, such as air compressors, air-conditioning equipment, boilers, main electrical switchboard, transformers, electric generator sets, and a pump room. REI-90 is recommended.
- **Office, presentation, and sales areas**. If each of these exceeds 250 m^2 then REI-90 is recommended.
- In general, **doors** shall have a fire resistance of at least half that of the fire sector in which they are located. Compartmentalisation must not be lost in the **service conduits** passing through the walls or floor structures, fire dampers, fibrosilicate panels, and rockwool, etc. may therefore be fitted.
- **Cable raceways, channels, and service conduits** passing through walls or floor structures shall be specially treated to ensure that the intended compartmentalisation is not compromised at those points. Elements such as special mortars, panels, and intumescent sacks can be used for this purpose.

7.3. Other protections

There are various sources of ignition, flammable products, and large quantities of paper (combustible material with a high fire load) in graphic-arts printing presses and workshops, which is why it is essential to keep them tidy and clean by means of the following recommended standards of good practice:

- Carrying out inspections and risk assessments for subsequent prevention, control, and minimisation.
- Applying the right maintenance schedule to the operating equipment, installations, and machines.
- Putting up **"You are here"** plans with evacuation routes and safety instructions.
- Preventing areas of saturation in storage areas and providing adequate waste management, for which purpose classified waste containers would be an appropriate collection measure.
- Applying appropriate cleaning standards in the areas surrounding machinery that produces combustible dust (paper and starch).
- Establishing procedures to inform contractors, visitors, and hauliers of the basic prevention and action measures in the case of emergencies at the facilities.

Paper cutting collection

- In the workplace, indicating the personal protection gear and anti-fire protection means.

- Fitting filters at the entrance of the extraction conduits of the newspaper printing rooms. The conduit must be provided with **easy-to-open panels or traps** for periodic inspection and cleaning.

Indications for anti-fire protection means

- **Solvents** used to **clean the presses** must have a **high flashpoint** (at least 38 ºC). In order to clean hot surfaces, the flashpoint must be at least 10 ºC above the surface temperature.

- Not blocking access to the extinguishers, hoses, and other general elements for fighting fires.

- Implementing **preventive measures** for worker safety, such as:

  - Using safety gloves for handling ink containers.

  - Wearing tight-fitting work clothes, and avoiding the use of bracelets, chains, or other personal items to prevent the risk of trapping.

  - Fitting safety showers with emergency eyebaths.

  - First-aid kits.

  - As regards the rotary newspaper machines, operating with several machines at once generates high noise levels. It is therefore recommended to use ear plugs or defenders.


Emergency eyes wash

7.4. Anti-theft protection

Any industrial establishment with customer-facing offices and/or sales premises is provided with electronic office-automation equipment and in some cases metallic money, which may be targeted by thieves. An appropriate measure would be to install a safe located in an area away from windows or walkways from which it would be visible or easy to access. Apart from money, this safe must contain the company's important documents such as deeds and invoices. It is also recommended to take the necessary security measures to prevent the removal of pre-press files, phototypesetting items, and printing plates given their strategic importance to the production process.

Safe

Anti-intrusion centre keyboard

7.4.1. Passive or physical protection

The aim of passive anti-theft protection is to act as a deterrent or hindrance to intrusions into the area being protected. This, in turn, can be subdivided as follows: peripheral protection (e.g. walls, fencing, bollards, and enclosure lighting), perimeter protection (e.g. doors, metal locks, grilles, and security glass), and internal or specific protection for metallic money (safes), computer equipment, documentation, machinery, tools, and merchandise.

7.4.2. Active protection

The purpose of active protection is to detect the presence of intruders in the industrial establishment and send an alarm signal to the anti-theft centre. Examples of active protection include external peripheral detection (e.g. infrared barriers), internal peripheral detection (e.g. magnetic contacts), volumetric detection (e.g. infrared or dual-technology sensors).

The alarm devices must be connected to the anti-theft centre of the establishment, and also with an external centre managed by an accredited security company. It is recommended that the connection between both centres be established by means of a supervised communications system (e.g. Intranet, Internet, or mobile telephony - GPRS, UMTS) or with anti-sabotage devices.

7.4.3. Human protection measures

Human protection measures include the company's own or subcontracted security guards. The company may enter into an assistance-service agreement with an external security company.

In general, **anti-theft protection** is based on the control of three complementary aspects:

Physical security	• Fencing • Grilles • Doors • Security glass • Etc.
Electronic security	• Alarm devices
Organisational security	• Security personnel • Safekeeping of keys • Control of security codes

> 08 Conclusions

There is a significant risk of fire in graphic-arts printing presses and workshops, hence the importance of establishing effective measures appropriate to each type of hazard.

Risk type	Incident in graphic-arts printing presses and workshops	Protective measures
Fire	• High accumulation of fire load (paper) • Solvents • Flammable inks • Alcohols • Explosive atmospheres due to paper and starch dust, or flammable vapours • Various sources of ignition (e.g. machinery and electricity) • Smokers	• Extinguishers • Fire-hose cabinets • Fire detection • Compartmentalisation of production and storage areas Upper level: • Fire-extinguishing carts • Fixed CO_2 extinguisher systems in technical rooms • Fixed foam extinguisher system in flammable stores • Automatic water sprinklers in paper stores • Compartmentalisation in technical rooms

Risk type	Incident in graphic-arts printing presses and workshops	Protective measures
Theft	• Cash, documentation, computer equipment • Damage resulting from theft	• Safes • Volumetric sensors, magnetic contacts, alarm communication centre. • Anti-sabotage systems • Supervised communications systems (e.g. Intranet, Internet, mobile telephony –GPRS, UMTS-) between the alarm communication centre and that of the security company
Other material damage	• Water damage (water-channel overspills, blocked downpipes, etc.) • Weather damage: lightning strikes, wind, torrential rain, snow, hail, etc.	• Maintaining downpipes, drains, and rainwater channels in good condition • Installation of lightning rods in areas with a high lightning-strike rate
Civil liability	• Fires affecting third parties • Explosions affecting third parties • Environmental • Occupational accidents	• Effective sectorisation from third parties • Own active and passive protection measures against fire • Waste management and pollution control • Safe hazardous-goods storage • Work risk prevention plans
Work risks	• Cuts, amputations, trapping, and impacts from extraction systems and printed-paper collection systems. • Contact with harmful substances • Electrical discharges • Hearing problems • Ergonomic stress due to repetitive manual work	• Development of work risk prevention • Handguards, dual actuation control, and protective screen • Emergency self-protection equipment • Warning signs • Instructions for use • Correct equipment maintenance • Ear plugs or defenders • Rotating rosters for repetitive tasks

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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