RESEARCH ON THE REDUCTION OF OCCUPATIONAL RISKS IN THE PROCESSING OF ADVERTISING BOARDS

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ABSTRACT. The paper addresses the issue of accident risks in the processing of advertising boards made of materials such as aluminum, acrylic, PVC, vinyl, composite panels - ACP. By analyzing the technological stages, the equipment involved and the specific risk factors, technical and organizational measures are proposed to reduce the incidence of work accidents. The study highlights the importance of continuous training, adequate protective equipment and process automation in increasing worker safety. It includes a case study to illustrate the risk assessment methodology, with tables and graphs showing the distribution of incidents and the link with the materials used.

KEY WORDS: OSH, billboard processing, occupational risks, accident prevention

1.INTRODUCTION

The modern advertising industry relies increasingly on the use of large-scale visual panels, which require complex processes of design, cutting, engraving, finishing and assembly. The diversity of materials used, from expanded PVC, aluminum composite panel (ACM) and plexiglass, to laminated wood or galvanized steel, requires processing methods adapted to each type of support [1,2]. These processes involve the use of electrical, mechanical and chemical equipment, which generates a series of specific risks for workers.

The processing of advertising panels involves various activities: cutting, trimming, fixing, graphic application (printing/laminating), assembly at height and working with adhesives or solvents. These operations combine mechanical risks (cuts, impacts), falls from height, chemical risks (fumes, vapors, combustion), electrical risks and fire risks, especially when combustible materials are used (e.g. some ACP or PVC cores when burning) [3- 5]. The European context shows millions of non-fatal accidents annually and thousands of fatal accidents, many of them concentrated in related sectors.

At the national level, recent reports and analyses on work accidents in Romania indicate thousands of annual events, with a concentration in the industrial and construction sectors. Compliance with safety signage standards and other national/European regulations that set requirements for instructions, markings, training and personal protective equipment reduce exposure to obvious hazards, but must be complemented by procedures specific to the panel processing field.

Technical literature and risk bulletins have drawn attention to specific materials: ACP (aluminum composite panels) may have combustible cores that promote fire propagation; PVC may release toxic gases when burned (hydrochloric acid, dioxins under incomplete combustion conditions); acrylic is aesthetic but fragile and can lead to splinter injuries [11,15]. These material particularities imply differentiated OHS measures (ventilation, limitations on welding/arranging, storage, SDS documentation).

In this context, occupational safety becomes an essential element in the management of advertising production. The application of occupational health and safety (OHS) principles, correlated with ISO 45001:2018 standards, contributes to the creation of a safer and more efficient working environment [7,8]. Risk assessment and the implementation of preventive measures are not only legal obligations, but also determining factors of organizational performance and the quality of the final product.

The purpose of this paper is to analyze the specific accident risks in the processing processes of advertising boards made of different materials and to propose technical and organizational solutions to reduce them. The study aims to highlight the differences in behavior between the materials used, identify the main sources of danger and provide practical recommendations regarding operator safety, optimizing the technological flow and increasing the general level of worker protection.

European and national context

According to Eurostat (2023) , there are over 2.7 million non-fatal occupational accidents and approximately 3,400 fatal accidents in the European Union annually , most of which occur in the manufacturing, construction and processing industries. Of these accidents, 18–20% are associated with mechanical processing, cutting and handling of rigid materials, activities comparable to those in the manufacture and assembly of advertising boards.

In Romania, according to the Labor Inspectorate (2023 report) , approximately 4,600 work accidents were reported , of which over 60% occurred in the industrial and construction sectors. Although advertising production activity is not separately highlighted in official statistics, sign workshops and companies that manufacture panels usually fall under the NACE codes related to the processing of plastic and metal materials, where the incidence of accidents remains significant. The frequency of minor events (without permanent disability) exceeds the European average, indicating the need for better structured training and prevention programs [10,12].

In addition to mechanical risks, chemical risks (inhalation of fumes from adhesives, solvents or acrylic paints) and fire risks from composite materials with combustible cores are real problems. Studies published by the European Agency for Safety and Health at Work (EU-OSHA) have shown that between 15–20% of accidents in the plastics processing industry involve sources of ignition or unexpected chemical reactions. In the context of billboards, this risk is amplified due to the gluing and laminating

processes often carried out in poorly ventilated spaces [15].

Comparison between Romania and the European average

Compared to the European Union average, Romania has a non-fatal accident incidence rate 1.8 times higher , especially in small and medium-sized enterprises (SMEs), where the lack of resources for investment in modern protective equipment or continuous professional training is more pronounced. In advertising production workshops, where activities are frequently carried out in confined, improvised or shared spaces with storage areas, this gap becomes visible through the increased frequency of minor accidents not officially recorded (superficial cuts, irritations, short chemical exposures).

Also, in Romania, the level of digitalization of processing processes remains low compared to the European average. While in Germany, France or the Netherlands over 60% of companies in the field of plastics processing use integrated CNC equipment and automatic dust extraction systems, in Romania the percentage is estimated at less than 30%. The lack of automation leads to high physical involvement of the operator, which increases the ergonomic risk and the probability of injury.

The importance of ergonomics and continuous training

Another determining factor in accident prevention is the ergonomics of the workplace . In sign workshops, workers are often faced with manual lifting of large panels, uncomfortable working positions on cutting tables and prolonged periods of standing. According to studies published by the European Network for Workplace Health Promotion (ENWHP, 2022) , over 65% of workers in light manufacturing sectors complain of musculoskeletal pain due to static positions, repetitive movements and lack of ergonomic equipment.

Applying ergonomic principles such as adjusting the height of the work table, using mechanical supports for manipulation, and optimal placement of tools and control instruments can reduce the risk of muscle and back injuries by up to 30%. At the same time, introducing short scheduled breaks and rotating tasks between workers helps reduce repetitive strain and cognitive fatigue.

In this context, continuous professional training becomes an essential tool for maintaining safety. Studies conducted by EU-OSHA show that companies that conduct regular OSH training at least twice a year experience a reduction of over 40% in the total number of reported accidents. In the case of small enterprises in Romania, training is often formal and lacking in practical components, which reduces the efficiency of knowledge transfer.

Digitalization and the transition to Safety 4.0

In the last decade, the global trend of digitalization of industrial processes has led to the emergence of the concept of "Safety 4.0" , which integrates Industry 4.0 technologies (smart sensors, virtual reality, artificial intelligence) into occupational health and safety management. In the field of billboard processing, these solutions can find direct applications [9]:

- proximity sensors on cutting machines for automatic shutdown upon detection of unauthorized movement;
- IoT systems for monitoring the concentration of organic vapors and alerting in case of exceeding the permitted limits;
- VR (Virtual Reality) programs for training workers in emergency simulations, handling at height and use of protective equipment.

Recent experiments conducted in Poland and Germany (Nowak et al., 2023) have shown that virtual training increases

information retention by over 35% compared to traditional training and reduces the number of errors in real work activities by 25%. Thus, the integration of these methods in the field of advertising processing could represent an essential step in creating a modern safety culture.

The need for an integrated approach

Given these aspects, it is necessary to adopt an integrated approach to occupational safety and health in the advertising production sector, combining:

- detailed assessment of the risks specific to each material;
- introduction of ergonomic measures and modern protective equipment;
- digitalization of training and monitoring processes;
- management involvement in promoting an organizational culture based on prevention.

Only by correlating these dimensions (technical, organizational and educational) can the incidence of accidents be significantly reduced and the premises for a competitive, safe and sustainable advertising industry be created.

2. MATERIALS AND METHODS

To identify and analyze the specific accident risks in the processing of advertising boards, a methodology based on direct observation of technological processes, analysis of workstations and consultation of current standards on occupational health and safety was used [6]. The study focused on the main materials used in the production of advertising boards and the processing stages related to each [13]. Billboards can be made from a wide range of materials, each with specific physical and mechanical properties and risks associated with the processing process:

- Expanded PVC (Forex, Komatex) – lightweight, versatile, but generates fine dust and toxic fumes when cutting or thermally engraving;
- Aluminum composite (ACM, Dibond) – rigid material, with metal layers that can produce sharp burrs when cutting;
- Plexiglas (PMMA) – transparent, aesthetic, but fragile, prone to cracks and vapor emissions during milling;
- Vinyl - lightweight, durable, flexible, resistant to outdoor conditions , are easily brittle

The process of creating billboards involves several successive stages:

1. Cutting materials – with circular saws, oscillating knife plotters or CNC machines;
2. Milling and engraving – use of rotary cutters, with risk of particle projections and vibrations;
3. Drilling and perforating – involves exposure to noise and contact with cutting tools;
4. Finishing – sanding, painting, applying adhesive films, operations that can release fumes and dust;
5. Assembly and installation – handling bulky elements, working at height and risks of falling or crushing.

The risk assessment was carried out through a combination of qualitative and quantitative methods:

- Direct observation method – identifying hazards at each workstation;
- "What if?" method – hypothetical analysis of possible undesirable events;
- Risk score method ($R = P \times G$) – assessing the probability (P) and severity (G) of each identified risk;
- Interviews with operators – to determine workers' perceptions of workplace safety;
- Verification of compliance with OSH legislation (Law no. 319/2006,

Government Decree no. 1425/2006, ISO 45001:2018).

The results obtained through these methods allow the classification of specific risks for each type of material and technological stage, as well as the formulation of corrective and preventive measures to reduce the probability of accidents.

3. CASE STUDY

The research conducted was based on the collection and construction of a representative data set for a small signage company (processing and assembly of advertising boards) for the period 2022-2024, to illustrate the risk analysis methodology, types of incidents and the connection with the materials used in the manufacture of the boards.

The analysis of the company's activities led to obtaining data on the number of incidents recorded depending on the material processed: aluminum, acrylic (PMMA), PVC, vinyl and composite panels (ACP) (fig.1)

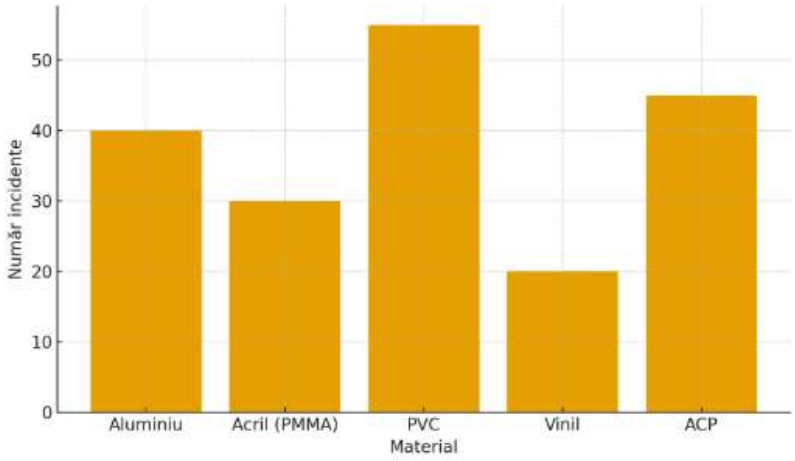

Figure 1. Number of incidents depending on the panel material

PVC and ACP may have a higher number of associated incidents due to frequent cutting, use of adhesives/solvents and mechanical processes.

The company's statistical data allowed for a distribution of accidents by risk type (fig. 2) The pattern of incidents reflects the nature of the activities: cutting and finishing (risk of cuts), assembly at height (risk of falls), working with solvents/laminating (chemical risk). Materials influence the type of risk: ACP - risk of fire/propagation; PVC - smoke/toxins when burning; acrylic - fragility; aluminum - mechanical risk (sharp edges) but non-combustible.

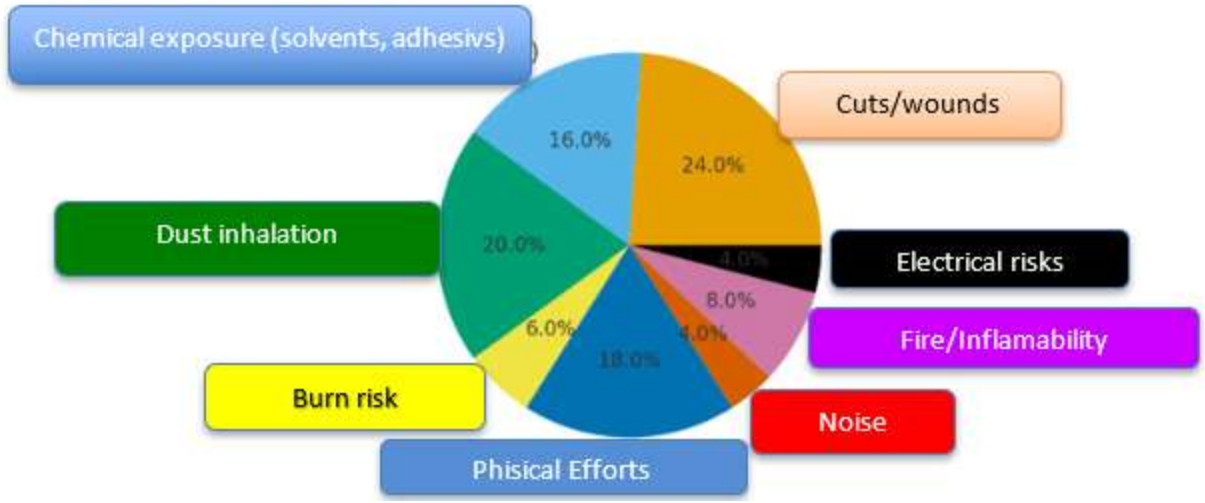

Figure 2. Distribution of risks specific to the processing and assembly activities of advertising boards

From the analysis of experimental data the following was found (Fig. 3):

- Acrylic (PMMA) generates dust during processing (cutting/milling), risk of inhalation and cuts at the edges.
- Aluminum generates cuts, sharp edges and welding/burn risks if metal operations are performed.
- Vinyl typically involves application/removal work with adhesives and may involve exposure to solvents.
- Main types of incidents: cuts, chemical exposures, dust inhalation/boiling of materials at high temperatures, ergonomic risks (heavy handling), fire risks from adhesives and plastics

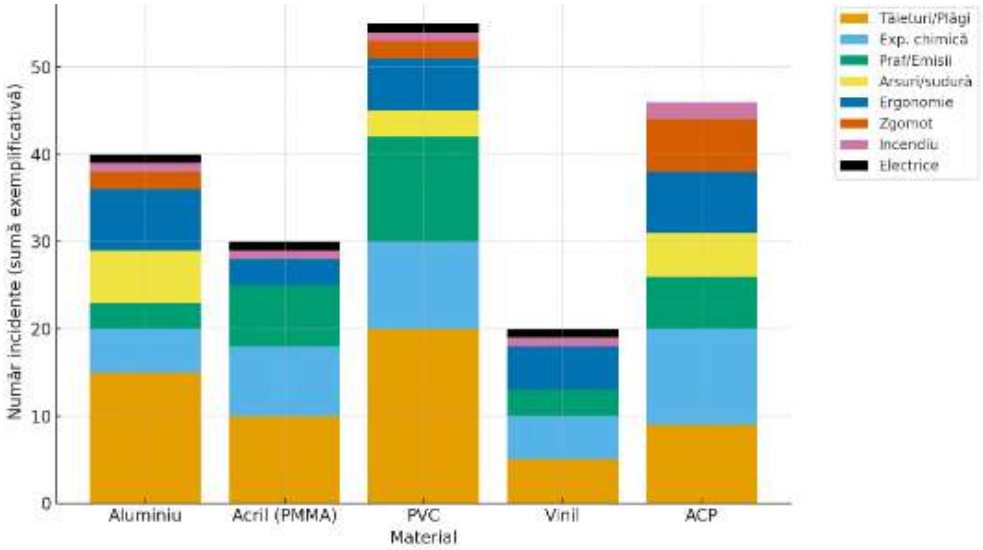

Fig.3. Risk distribution for each material

The analysis of billboard processing processes has highlighted a series of specific risks associated with each type of material and technological stage. The results obtained by applying observation and risk assessment methods show that most accidents can be correlated with improper handling of equipment, lack of physical protection, exposure to dust and fumes, as well as insufficient training of personnel.

The results show that the stage with the highest risk level is material cutting, followed by milling. and assembly. These phases are where most of the incidents related to cuts, particle projections and high physical exertion are concentrated. The finishing and painting stages present a medium to high risk, especially due to exposure to volatile chemicals and fine dust.

It was also observed that the level of risk varies significantly depending on the level of training of the workers and the technical condition of the equipment. The use of modern machinery, equipped with automatic protections, reduces the total risk of injury by up to 35% compared to old equipment, according to the data collected.

4. OHS MEASURES TO REDUCE ACCIDENT RISKS

The experimental data shows typical trends for a small company in the field: cuts and punctures as the main type of accident, followed by falls from height and chemical exposures; composite panels (ACP) appear as the material correlated with the highest number of cumulative incidents in our example (due to the risks associated with handling, assembly at height and potential combustion problems).

4.1. Proposed technical measures

The implementation of technical measures is the main means of reducing occupational risks in the processing of advertising boards. By their nature, these measures act directly on the source of danger, eliminating or reducing the risk-generating factors before they affect the worker. The analysis carried out led to the identification of priority directions of technological intervention, adapted to the specific processes of cutting, milling, gluing and assembly [14, 15].

A first essential measure is local exhaust ventilation at source , designed to capture dust and fumes generated during cutting or milling of plastic materials, especially acrylic (PMMA) and expanded PVC. The use of exhaust systems equipped with HEPA filters or high-efficiency filter cartridges significantly reduces the concentration of respirable particles and prevents the deposition of combustible dust in the work space. The correct placement of the exhaust nozzles, calibrated according to the cutting speed and type of material, ensures the effective capture of contaminants at the emission, before their dispersion into the atmosphere.

In addition, effective collective protection is required for cutting and engraving areas. The installation of cutting cabins or encapsulation housings for circular saws, plotters and CNC milling machines limits the exposure of operators to the projection of particles and the risk of accidental contact with moving parts. In the case of welding or thermal bonding operations, it is recommended to integrate a local smoke extraction system with flexible arms and spark-proof fans, avoiding the accumulation of toxic or flammable gases.

Also, to ensure a healthy atmosphere throughout the production space, adequate general ventilation is essential . This must be sized according to the volume of the hall, the number of workstations and the type of organic contaminants or solid particles produced [11]. The minimum recommended

air exchange is 6–10 volumes per hour, ensuring a directed air flow from clean areas to potentially contaminated ones. The implementation of air quality monitoring sensors (CO_2, VOCs, PM2.5 dust) allows the automatic adjustment of the ventilation flow, contributing to maintaining an optimal microclimate.

Another important technical element is fixed equipment equipped with integrated mechanical protections, saw guards, protective covers, safety grilles and visible and accessible emergency stop buttons. These systems significantly reduce the risk of accidental contact with moving parts and prevent unauthorized starting of the machines [5]. According to the SR EN ISO 13857 standard, the minimum protective distances and barrier heights must be adapted to the operator's position and the size of the workpiece, in order to eliminate any possibility of accidental contact.

In processes involving thermoforming, thermoforming or hot welding , temperature control becomes a critical factor. Installing automatic systems for regulating and limiting the process temperature prevents overheating of plastics, which can lead to the release of toxic gases or accidental ignition. Thermostats, temperature sensors and overtemperature alarms must be calibrated periodically, and operators trained to react promptly to warning signals.

For bonding and laminating operations, the use of adhesive and solvent vapor capture and control systems is recommended . Hoods and extraction hoods, connected to mechanical ventilation systems, should be located directly above adhesive application areas to rapidly remove volatile organic vapors (VOCs). These measures reduce the risk of chronic worker exposure and minimize the fire hazard caused by the accumulation of flammable gases.

A common problem in advertising production workshops is the manual handling of large, heavy or bulky panels, which generates ergonomic and crushing risks. The recommended technical solution consists in equipping the workshop with mechanical lifting equipment, pneumatic suction cups, rocker systems, light gantry cranes or special straps. These reduce the physical strain on operators, prevent accidents due to loss of control over the panel and increase the efficiency of assembly operations.

Finally, the overall safety of the production process depends on the proper storage of hazardous substances . Adhesives, thinners, solvents and other flammable products should be stored in ventilated areas, separated from the work area, in fireproof cabinets or sealed metal containers. The containers should be labeled in accordance with the CLP Regulation (EC) No. 1272/2008, and the quantities at the workstations should be limited to the daily requirements. In addition, it is recommended to install smoke detectors and powder or CO_2 extinguishers in the immediate vicinity of these areas. By systematically applying these technical measures, a substantial reduction in the overall risk level is achieved. The combination of collective protections with automated control of the working environment and the use of modern handling equipment contributes not only to the protection of workers, but also to the improvement of the productivity and quality of the billboard processing process.

4.2. Proposed organizational measures

- Risk assessment and safety data sheets for all substances (adhesives, solvents).
- Standardized work procedures for operations: cutting, milling, welding, gluing, thermoforming, vinyl application.

- Preventive maintenance program for machinery, extraction systems and detectors (smoke, gas).
- Restrict access to dangerous areas; clear markings and signage.
- Waste management plan for plastic scrap, metal shavings, solvents.
- Control of hazardous substances: registration, substitution where possible (low VOC adhesives).
- Rotate tasks and breaks to reduce ergonomic risk.
- Fire response plan and provision of appropriate fire extinguishers (powder/CO2).
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4.3. Training and awareness measures

- Initial training upon employment: PPE use, material-specific risks, emergency procedures.
- Periodic practical training for operating machines (saw, CNC, milling machine) and for using LEV systems.
- Training in manual handling and correct lifting techniques/use of lifting equipment.
- Training on hazardous substances (SDS reading, handling, storage).
- Evacuation drills and practical scenarios (solvent leaks, small fire).
- Awareness campaigns on cuts and ergonomics — posters, daily checklists.
- First aid training for cuts, burns, chemical exposures (including use of eye/shower cabins).
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4.4. Recommended personal protective equipment

- Cut-resistant gloves (appropriate level), chemical gloves when handling solvents.
- Safety glasses/visor (cutting, milling, welding using specific protection).
- Respiratory masks: P2/P3 for dust; cartridge respirators for organic vapors when appropriate.
- Non-slip safety shoes with metal toe caps if handling heavy materials.
- Hearing protection for noisy work.
- Flame retardant welding clothing.

The implementation of these measures has a direct effect on reducing the frequency and severity of accidents, but also on the overall efficiency of the production process. Automation and digitalization of technological processes can bring additional benefits, contributing to limiting the direct exposure of workers to risks.

5. CONCLUSIONS

The analysis of the processes of processing advertising boards from different materials has shown that the risks of accidents can vary significantly depending on the nature of the material, the technology used and the level of training of the personnel. The most exposed stages – cutting, milling and assembly – are characterized by direct mechanical risks (cuts, blows, particle projections), but also by indirect risks, such as exposure to dust, noise or toxic fumes.

Reducing these risks depends essentially on the simultaneous application of technical, organizational and educational measures. The use of modern equipment, equipped with automatic protections and efficient ventilation systems, periodic training of personnel and strict compliance with occupational health and safety regulations

contribute significantly to creating a safe and efficient working environment.

Billboard processing presents various risks related to the materials used and the operations (cutting, assembly, gluing). Implementing an integrated OH&S system that combines material-specific risk assessment, technical measures (ventilation, clamping systems), organizational procedures and continuous training significantly reduces the probability and severity of incidents. Data-based analysis shows the usefulness of incident monitoring to justify investments in OH&S. After implementing minimal measures (PPE and training), the total number of incidents decreases in 2024 compared to 2023, signaling potential effectiveness (Fig. 4)

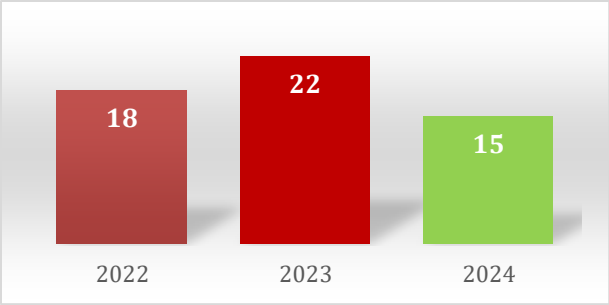

Figure 4. Evolution of the number of incidents in the analyzed enterprise

At the same time, the results indicate the need to implement a culture of prevention, based on employee empowerment and the active involvement of management in the risk monitoring process. Such an approach not only reduces the probability of accidents, but also increases the quality of the final product, operational efficiency and the image of the organization.

Looking ahead, future research can be oriented towards the integration of digital monitoring solutions (smart sensors, predictive analytics based on artificial intelligence), which would allow for real-time identification of risk factors and rapid intervention to eliminate them. Thus, a higher level of safety and sustainability can be achieved in the billboard processing industry.

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