Hazard And Risk Analysis In Spray Painting And Powder Coating Of An Automobile Industries

G. S. Aswinprasath, M. Sathyanathan, M. Karthikeyan, K. Visagavel, PSS. Srinivasan, P. Rajmohan

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ABSTRACT
In most of the industries, fire imposes the greatest threat both in terms of financial loss as well as loss to life and property. The presence of combustible materials, their physical arrangement, the likelihood of ignition and the necessary amount of heat required are the factors on which the risk of fire depend upon. It is widely recognized that solvents and paints play an important in many areas of automobile industry. This paper concentrates on the causes of fire and explosion inside the paint shop section of an automobile industry. Thus it considers how fire risk is affected by the storage and handling of flammable substances in the workplace and the effectiveness of the existing measures. This pilot study shows a gap analysis between the existing control measures and the required IS/OSHA/NFPA standards for fire and explosion safety while working with paints and solvents. It focuses on solvents and thinners that are highly flammable and makes the area a high risk zone.

KEYWORDS: Spraypainting,powdercoating,flashpoint,explosive limit.

INTRODUCTION
Fire, a process in which substances combine chemically with oxygen from the air and typically give out bright light, heat, and smoke leading to combustion or burning. For premises where flammable substances are handled or stored, the fire precautions will comprise both ‘process fire precautions’ (i.e. those which affect fire initiation and the early stages of fire growth) and ‘general fire precautions’ (e.g. the provision of firefighting and fire detection, and emergency routes and exits). The application of paints and solvents which act as the combustible material, when handled either by spraying, dipping or other processes, can present fire or explosion hazards. These results not only from the solvent vapors that are emitted but also from mixed paint deposits which may be liable to spontaneous combustion from subsequent drying or baking processes. The term “solvents” refers to liquid organic chemicals used to dissolve solid materials. Solvents can be made from natural sources such as turpentine and the citrus solvents, but most are derived from petroleum or other synthetic sources. Solvents are used widely because they dissolve materials like resins and plastics, and because they evaporate quickly and cleanly. Two properties which affect a solvent’s capacity to cause fire and explosions are evaporation rate and flash point. In general, the higher a solvent’s evaporation rate, the faster it evaporates and the more readily it can create explosive or flammable air/vapor mixtures. All, solvents, flammable or not, should be isolated from sources of heat, sparks, flame, and static electricity. The products used by the paint department require special storage protocols so that they do not become a danger to those working with them, to those
working near them or to the general public. Dillon Consulting Ltd. states that solvents and thinners are incompatible with oxidizing agents: as oxidizing agents increase the risk of fire if they come into contact with flammable materials. Therefore, thinners and solvents should be stored away from agents such as peroxides. According to Occupational Safety and Health Act 1984 and Occupational Safety and Health Regulation 1996, use of flammable materials in spray painting (e.g. organic solvents), increases the risk of fire and explosion because of the amount of solvent vapor in the air. Solvents Industry Association has also suggested that for a liquid fire sufficient air and high enough temperature have to be present to ignite the liquid. The temperature may be from the ignition source such as a static spark or from the liquid itself being above its auto-ignition temperature. The study focused on:

- Areas such as the paint storage area, the paint kitchen, the rag/tag area and the painting area the paint-baking oven and the CO2 bank.
- Flammable substances considered were flammable solvents such as thinner and primer and the paint, which was used for painting the automobile parts.
- The study concentrated on storage and handling of paints and solvents in the workplace and control of ignition sources.

**ii Spray Painting And Powder Coating:**

**Spray painting:**

Spray painting, including electrostatic spray painting, is a process by which liquid paint is applied under pressure to an object. Spray painting may be carried out by hand or automatically. There are several methods used to atomize the paint for spraying:

- using a conventional air compressor – air is driven across the mouth of a small outlet under pressure to draw liquid paint out of the container and produce an air-paint mist from the nozzle of the spray-gun
- airless spray painting – the paint container is pressurized pushing the paint to the nozzle where it is atomized by the spray gun, or
- electrostatic spray painting – an electric pump drives the electro statically charged liquid paint out of the nozzle which is then applied to the object which is earthed.

**A. Powder coating:**

Powder coating is a process by which electro statically charged powder is applied onto an earthed object. Spray painting and powder coating are carried out in a variety of industries. For example, items that are commonly spray painted include motor vehicles, buildings, furniture, white goods, boats, ships, aircraft and machinery.

**III Assessing The Risks:**

Hazards have the potential to cause different types and severities of harm, ranging from minor discomfort to a serious injury or death. For example, exposure to spray painting or powder coating chemicals can adversely affect a worker’s health in ways ranging from minor illness (for example, headaches) to major illness (for example, asthma). Many liquid paints and powder paints contain flammable substances. Spray painting vapors and mists, as well as powder paints used in powder coating can spread rapidly, particularly in an enclosed space, and create a potentially explosive atmosphere. If the aerosol, mist, vapor or powder paint is ignited, for example by static electricity, a lit cigarette or spark, it could result in an explosion that could destroy the building and kill or injure anyone nearby. Each of the outcomes involves a different type of harm with a range of severities, and each has a different likelihood of occurrence. Under the WHS Regulations, a risk assessment is not mandatory for spray painting or powder coating, however, it is required for specific situations, for example when working with asbestos. In many circumstances a risk assessment will assist in determining the control measures that should be implemented. It will help to:

- identify which workers are at risk of exposure
- determine what sources and processes are causing that risk • identify if and what kind of control measures should be implemented, and
- check the effectiveness of existing control measures. The following questions may help to assess the risk:
  - How often, and for how long, will exposure to the hazard occur?
  - In the event of exposure to the hazard, will the outcome be severe, moderate or mild?
  - How do workers interact with the hazard (for example, being exposed to hazardous chemicals by breathing it in or skin contact)?
  - Is there evidence of contamination (for example dust or fumes visible in the air, chemical odors, spills, splashes)?
- What are the conditions under which spray painting is carried out (for example, confined space)?
- What are the skills, competence and experience of the operator?
IV Common Spray Painting And Powder Coating Hazards:

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Potential harm</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous chemicals</td>
<td>Dermatitis, respiratory illnesses and cancers. Some hazardous chemicals are also fire and explosion risks</td>
<td>Paints, solvents, adhesives, resins, rust removers, rust converters, lacquers and degreasers</td>
</tr>
<tr>
<td>Fire and explosion</td>
<td>Serious burns and death, exposure to projectiles and damage to property</td>
<td>Flammable paints and solvents may come into contact with an ignition source. Combustible dusts can be used in powder coating</td>
</tr>
<tr>
<td>Confined spaces</td>
<td>Exposure to hazardous chemicals, unsafe oxygen levels, potential for fire, explosion and engulfment</td>
<td>Spraying inside the cavity of vehicles, ships, aircraft or tanks</td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td>Injection injuries, being caught by moving parts of machinery can cause fractures, bruises, lacerations, dislocations, permanent injuries or death</td>
<td>Spray booths, sanding, grinding equipment, airless spray equipment, compressed air</td>
</tr>
<tr>
<td>Working at height</td>
<td>Falling objects, falls, slips and trips of people can cause fractures, bruises, lacerations, dislocations, concussion, permanent injuries or death</td>
<td>Spray painting trucks, ships, aero planes or bridges</td>
</tr>
<tr>
<td>Manual tasks</td>
<td>Overexertion, sustained awkward postures or repetitive movement can cause muscular strain</td>
<td>Repetitive spraying action, lifting and pushing objects into place</td>
</tr>
<tr>
<td>Electricity or static electricity</td>
<td>Exposure to electricity can cause shock, burns or death from electric shock. Electricity and static electricity are also sources of ignition</td>
<td>The use of electrical equipment, wiring of equipment and electrostatic charges</td>
</tr>
<tr>
<td>Heat or high humidity</td>
<td>Exposure to heat or high humidity can cause burns, heat stroke and fatigue</td>
<td>Wearing impervious PPE or working outdoors or in a poorly ventilated workplace</td>
</tr>
<tr>
<td>Noise</td>
<td>Exposure to loud noise can cause permanent damage to hearing</td>
<td>Noise from pumps, compressors and spray booths</td>
</tr>
</tbody>
</table>

V Hazard Categories Of Spray Painting Or Powder Coating Substances:

<table>
<thead>
<tr>
<th>High risk chemicals</th>
<th>A hazardous chemical should be considered as high risk if it is:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>• a chemical that is carcinogenic</td>
</tr>
<tr>
<td></td>
<td>• a chemical that is mutagenic, geotaxis or has reproductive hazards</td>
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<tr>
<td></td>
<td>• a chemical which affects the central nervous system (which can also affect hearing due to autotoxin effects). That is, they may cause hearing loss or exacerbate the effects of noise. Evaluating the use of these chemicals should be carried out in conjunction with the Code of Practice: Managing Noise and Preventing Hearing Loss at Work.</td>
</tr>
<tr>
<td></td>
<td>• a skin or respiratory sensitizer or if it is corrosive or has acute irritant effects</td>
</tr>
<tr>
<td></td>
<td>• a chemical which causes severe effects after a single, repeated or prolonged exposure</td>
</tr>
<tr>
<td></td>
<td>• a flammable liquid, vapor or aerosols</td>
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<tr>
<td></td>
<td>Many chemicals that are used in spray painting, including 2-part polyurethane paints containing isocyanides and toluene (an ingredient in many oil-based paints), and in powder coating, such as triglycidyl isocyanurate, hydrofluoric acid and chromic acid are known to present significant health risks and should be assessed as high risk.</td>
</tr>
</tbody>
</table>

| Medium risk chemicals | Medium risk hazardous chemicals include any substances that contain organic solvents that are not already assessed as high risk, or flammable liquids or combustible dusts. |

| Low risk chemicals | Hazardous chemicals that are low risk include any other substances not already assessed as high or medium. |

VI Controlling The Risks:
The Hierarchy Of Control Measures:

Some control measures are more effective than others. Control measures can be ranked from the highest level of protection and reliability to the lowest. This ranking is known as the hierarchy of control. You must always aim to eliminate a hazard and associated risk first. If this is not reasonably practicable, the risk must be minimized by using one or more of the following approaches:

- **Substitution** – for example:
  - use a water-based paint instead of an organic solvent based coating
  - use a brush or roller instead of a spray gun
  - use a triglycidyl isocyanurate-free (TGIC) powder coating instead of one containing TGIC
use high volume low pressure (HVLP) spraying rather than airless spraying. Use a low hazard cleaning solvent

- **Isolation** – Conduct all spray painting in a spray booth ensures that other workers are not affected by the spray painting.
- **Implementing engineering controls** – Use control measures such as ventilation systems, including spray booths, to reduce exposure to vapors and aerosols.

If risk then remains, it must be minimized by implementing administrative controls, so far as is reasonably practicable, for example restricting access to spray painting areas or keeping the quantity of hazardous chemicals to minimum in the spray painting area.

Any remaining risk must be minimized with suitable personal protective equipment (PPE), for example breathing protection, gloves, aprons and protective eyewear.

Administrative control measures and PPE rely on human behavior and supervision, and used on their own, tend to be least effective in minimizing risks.

A combination of these control measures may be required in order to adequately manage the risks with spray painting and powder coating. You should check that your chosen control measure does not introduce new hazards.

**VII Controlling The Risks Of Spray Painting:**

**Spray painting in spray booths:**

Spray booths are enclosed or partially enclosed structures designed to prevent or reduce exposure to hazardous chemicals or vapors. A spray booth should be used when spray painting with a hazardous chemical, except when:

- the shape, size or weight of an article cannot be easily moved or fit into a spray booth, for example, painting a building, bridge or a large boat, or
- the painting involves minor work such as spotting or touch-ups, for example, painting a scratch or stone chip on a car (painting a car panel with two-pack polyurethane paint would not be regarded as minor work).

**Types of spray booths include:**

- Open-faced spray booths generally have two walls, roof with air extraction, a filtered rear wall and an open front.
- Enclosed type batch booth is a room or large cabinet where the operator enters and spraying is conducted. The airflow is either down draught, cross draught, end draught or any combination thereof.
- Tunnel or production spray booths for mass produced items requiring a continuous painting application process. These booths are usually down draught or cross draught and have open ends.
- Full downdraft spray booths, where air enters the booth from the ceiling through a filtering system, and moves downwards vertically. Heavy and large objects, like cars, which are not easy to handle are often painted in the down draft spray painting booths.
- Semi downdraft booths, where fresh air enters the booth from outside the building, is ducted through the roof intake filters, and is drawn towards the exhaust wall of the booth where it is exhausted through filters.

**Spray booths should:**

- be designed, constructed and installed to comply with AS/NZS 4114.1: Spray painting booths, designated spray painting areas and paint mixing rooms – Design, construction and testing and AS/NZS 4114.2: Spray painting booths, designated spray painting areas and paint mixing rooms – Installation and maintenance.
- be fitted with an exhaust capture system and a ventilation system that includes a filter for removing airborne contaminants
- have ventilation systems capable of producing a minimum air movement of: 0.3 m/s for a full downdraft booth 0.4 m/s for electrostatic spraying 0.5 m/s for any other booth.
- be inspected at regular intervals and maintained according to manufacturer’s specifications, and
- have a sign indicating the time people should allow for chemicals to clear before entering the spray booth.

**Spray booth ventilation:**

Control systems should operate a pre-purge cycle to remove any residue contaminants and also operate a minimum of a 5 minute post-purge period following spraying. Whenever possible, the spray should be directed towards the exhaust air outlet of a booth. For example, when spraying a tall object in a down-draught booth no spraying should be performed above shoulder height. Extension poles or lift platforms should be used so that the operator can get above the object and spray towards the air exhaust outlet in the floor. The spray painter should never be positioned between the spray gun and the exhaust air outlet. See Figures 1 to 8 below for further guidance.
Fig. 1: The operator is exposed to overspray because of poor positioning in relation to the airflow.

Fig. 2: To avoid overspray, the article should be rotated rather than the operator spraying against the airflow.

Fig. 3: The spraying with a ‘short’ nozzle may cause overspray of the operator.

Fig. 4: Spraying with a ‘long’ nozzle avoids overspray of the operator.

Fig. 6: The use of staggered work positions avoids overspray of the operators.
VIII Controlling The Risks Of Powder Coating:

- Powder coating is a process by which powder is applied onto a charged object. It is the electrostatic charge on the powder and the object that will make the powder stick onto the surface of the object being sprayed. It is through powder coating process that workers are more likely to encounter hazards and risks associated with the use of electrical equipment, for example, static electricity and potential ignition sources. Workers are also more likely to be exposed to triglycidyl isocyanurate and experience adverse health effects.

Hazardous chemicals Triglycidylisocyanurate (TGIC):
- TGIC is classified as a hazardous chemical and is commonly used in powder coating activities. It is:
  - a skin sensitizer
  - toxic by ingestion and inhalation
  - genotoxic, and
  - capable of causing serious eye damage. You should check safety data sheets and labels to determine if the product you are using contains TGIC.

- Powder coatings containing TGIC are applied by electrostatic process. Workers who may come into direct contact with TGIC powder coatings include persons:
  - filling hoppers
  - manually spraying powder paint, including ‘touch-up’ spraying
  - reclaiming powder
  - emptying or cleaning industrial vacuum cleaners
  - cleaning powder coating booths, filters and other equipment, and
  - cleaning up major spills of powder coating.

Surface preparation chemicals Hazardous surface cleaning or preparation chemicals are commonly used in the powder coating industry. Active ingredients include:
- potassium or sodium hydroxide (may cause severe burns)
- hydrofluoric acid or hydrogen difluoride salts (may cause severe burns with toxic systemic effects. Skin contact with concentrate may be fatal. Special first aid requirements apply, e.g. calcium gluconate)
- chromic acid, chromate or dichromate solutions (may cause cancer, burns and skin sensation), and
• other acids, for example, sulphuric acid (may cause severe burns). You should check the label and safety data sheets of all surface preparation chemicals and implement systems for safe handling, storage, spill cleanup, first aid and worker training. Eye wash and shower facilities and specific first aid items may also be needed.

Fig. 10: Example of a local exhaust ventilation system suitable for powder coating activities.

Administrative Controls:

Administrative controls should be used to support other measures in order to reduce exposure of workers to hazards associated with powder coating activities. Administrative controls include:

• work practices designed to avoid the generation of dust
• restricting access to spray areas
• ensuring workers are never between the object to be sprayed and the airflow of contaminated air
• situating the articles to be sprayed sufficiently within the booth to avoid rebound
• implementing good personal hygiene practices, for example, powder coating dust should not be allowed to collect on the face, exposed body areas should be thoroughly washed and overalls should be regularly cleaned
• storing powder coating and waste powder in a designated area with restricted access
• cleaning booths and surrounding areas on a regular basis
• promptly cleaning-up spills of powder coatings to reduce the spread of TGIC
• using a vacuum cleaner with a High Efficiency Particulate Air filter for clean-up operations and not using compressed-air or dry sweeping

• vacuuming work clothing as an initial method of decontamination
• emptying vacuum cleaners in the booth and under exhaust ventilation • taking care to avoid the generation of dust during disposal of waste powder
• baking waste powder in the original box for disposal to landfill as a solid
• ensuring all electrical equipment is switched off before cleaning spray guns
• keeping the quantity of hazardous chemical to a minimum at the workplace.
• cleaning spray guns with a solvent that has a high flash point and, have low vapor pressure at the ambient temperature
• ensuring that incompatible chemicals are not stored together, e.g. flammable and oxidizing
• regularly checking that plant and equipment are being cleaned and maintained, including ventilation and spray equipment and filters, and
• proper induction training and general training of workers

IX Electrical Risks:

Electricity used in spray painting poses unique health risks including:

• electrocution from direct or indirect contact with electricity, and
• burns – flashes and arcing due to short-circuiting may lead to severe tissue burns or the ignition of flammable gases. Electrical equipment should be kept at a safe distance from spray painting exclusion zones. This includes fans, turntables, drying lamps, fixed lighting and switches, heating equipment, electrical appliances used during cleaning and repairing operations and appliances used to mix paint formulations.

Operating electrical equipment that is damaged or not designed to give explosion protection in spray painting and paint mixing areas creates an immediate risk. Further guidance is available in the Code of Practice: Managing Electrical Risks in the Workplace.

Static electricity:

Static electricity charges can be generated during a spray painting process if two differently charged materials come into contact. A common source of static generation is steam, air or gas containing particulate matter flowing from any opening in a pipe or hose. Static electricity discharge is most likely to happen during mixing and pouring of hazardous chemicals, specifically when the containers of hazardous chemicals are not correctly earthed.

Static electricity charges can be generated in any spray painting process if two differently charged materials come into contact. It can be generated by:

• touching two metal cans together during decanting
• clothing or synthetic fibers prone to accumulation of static charge including nylon, pure wool, wool blends (unless treated) and non-conducting footwear
• liquid flowing in pipes or vessels, and
• airless spray painting using high fluid pressure (control this by electrically earthing the airless spray gun and any conductive article that is being sprayed including a container that the flow from the gun is directed into).

**X Ppe Recommended For Common Spray Painting And Powder Coating Hazards:**

<table>
<thead>
<tr>
<th>PPE TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyes, face and head protection</td>
</tr>
<tr>
<td>Hearing protection (e.g. ear muff and ear plugs)</td>
</tr>
<tr>
<td>Gloves and clothing</td>
</tr>
<tr>
<td>Foot protection (e.g. boots and shoes)</td>
</tr>
<tr>
<td>Respiratory protective devices (e.g. dust masks, half face respirators and air supplied respirators)</td>
</tr>
</tbody>
</table>

**RESULTS AND DISCUSSIONS**

**Paint Storage:**
As per OSHA 1910.106/ NFPA 30, suitable fire control devices, such as small hose or portable fire extinguishers, shall be available at locations where flammable or combustible liquids1, open flames and smoking shall not be permitted in flammable or combustible liquid storage areas. Fire protection system shall be sprinkler, water spray, carbon dioxide, or other system should be in place. Though, all the above requirements are met by the organization, the sprinkler system is not in place and has to be installed.

As per IS 9109:2000 Paint containers shall be supported either by resting on the ground or on masonry supports. Wood or steel supports without fire-proofing shall not be permitted; all containers shall be suitably earthed to dissipate static charge, the containers’ vents shall be provided with flame arrestors or pressure-vacuum vent and firefighting measures should be in place. On comparing its seen that, the thinner and paint containers are opened/cut using a brass hammer so as to avoid electrocution. Also, flame proof lighting is being provided.

**Paint booth:**
OSHA 1910.106/ NFPA 30 say that mechanical exhaust ventilation system designed to provide for a complete change of air within the room at least six times per hour and All nonmetallic equipment and piping where an ignitable mixture could be present shall be given special consideration and all necessary firefighting systems should be in place. 29CFR 1926.66 states that areas should be illuminated through glass panels or other transparent materials, only fixed lighting units shall be used as a source of illumination. The paint shop is well illuminated with flame proof lighting and has proper firefighting installations. As per 1926.66(c)(9)(i) all metal parts of spray booths, exhaust ducts, and piping systems conveying flammable or combustible liquids or aerated solids shall be properly electrically grounded in an effective and permanent manner. The IS 9109:2000 states all lighting fittings and switches shall be of the enclosed type.

**Conclusion:**
An organization’s asset is its workforce, the property it deals with and the surrounding environment. The standards have been formulated by various regulatory boards so as to have zero accidents and hence no loss of life, no property loss and no environmental effect. It is mandatory to abide by these regulations so as to achieve a 100% profit both in terms of production and safety. This paper tried to make a gap analysis between the existing safety measures and that recommended by various regulatory bodies. The automobile industry taken into consideration has in no means sacrificed to follow the safety norms and as can be clearly seen has taken safety as an utmost important aspect along with its production interest.

**REFERENCES**