



Fire Risk Analysis in The Paint Shop of An Automobile Industry

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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.

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1. 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

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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.

2. Fire Risk Analysis Process

Fire risk is defined as the product of the probability of fire occurrence and the consequence or extent of damage to be expected on the occurrence of fire. Fire hazard not only effects life but also property and the environment. In this study, fire risk analysis is carried out in five areas within the paint shop: the paint storage area, the paint kitchen, the rag/tag area, the painting booth and the CO₂ bank. The risks associated in these areas are shown in the table below:

| Area | Raw Materials | Risk |
|----------------------|-----------------------------|---|
| Paint Storage | Flammable paints, Thinner | Fire hazard due to storage of flammable paint and thinner |
| Paint Kitchen | Flammable paints, Thinner | 1. Fire due to flammable paint and thinner. 2. Fire due to mobile phones inside the paint kitchen |
| Rag/Tag area | Thinner | Fire due to Thinner |
| Painting booth | Thinner, Flammable paints | 1. Fire due to storage of thinner inside the paint booth 2. Fire due to flammable paints and fumes |
| Paint baking oven | Flammable paint fumes | Fire and explosion hazard due to explosive and flammable paint fumes |
| CO ₂ Bank | CO ₂ , PNG lines | Fire due to bursting of PNG lines |

Table 1: List of Fire Risks Associated with the Paint Shop.

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- As per the MSDS of Thinner it is seen that OSHA Regulatory classifies this material as hazardous under OSHA Regulations. Section 3 of the MSDS indicates thinner to be highly combustible liquid and vapour. Section 5 illustrates the fire fighting measures of thinner as follows:
 - Flash Point: 114° F or 45.5°C
 - Explosive Limit: Lower: 1.5%, Upper: 7.0%
 - Auto ignition Temperature: 670°F or 354°C
 - OSHA Flammability Class: Combustible Liquid-Class II
- The vapours of thinner are heavier than air may travel along the ground or may be moved by ventilation and ignited by pilot lights, other flames, sparks, heaters, smoking, electric motors, static discharge, or other ignition sources at locations distant from material handling point. The extinguishing media that is suggested to be used is carbon dioxide, dry chemical and regular foam. Also, water may be used to keep fire-exposed containers cool until fire is out. Section 7 illustrates the handling and storage of thinner as:
 - Handling: All hazard precautions given in the data sheet must be observed. Avoid contact with eyes, skin and clothing. Wash thoroughly after handling. Use only with adequate ventilation. Do not breathe vapours or spray mist. Do not take internally. Close container after each use.
 - Storage: Store material in a cool, well-ventilated area. For maximum product quality, avoid prolonged storage at temperatures above 75°F (25°C). Do not use or store near heat, sparks, or open flame. Keep container tightly closed. Avoid contact with incompatible materials.
 - On analysing the high risk zones within the paint shop, the control measures which are kept in place are described as below:

Table 2: Existing Control Measures.

| Area | Controls |
|----------------|---|
| Paint Storage | Open flames and smoking shall not be permitted in flammable or combustible liquid storage areas, fire protection system like carbon dioxide, water spray is provided |
| Paint Kitchen | Fire extinguishers, no smoking area, flame proof lightening, CO ₂ flooding system, prohibition of mobile phones, proper grounding to prevent static electricity. |
| Rag/Tag Area | Fire extinguishers, no smoking area, flame proof lightening, CO ₂ flooding system, prohibition of mobile phones, proper grounding to prevent static electricity. |
| Painting Booth | Limited quantity is being stored. |

| | |
|----------------------|--|
| | Flame proof fittings, no smoking area, mobile prohibition, restricted entry, CO ₂ flooding system. Fire extinguisher, no smoking area sign board, proper grounding to prevent static electricity. |
| Paint baking oven | Flame proof lightening, CO ₂ flooding system, trained and experience person, safety caution displayed. |
| CO ₂ Bank | Safety valves, Isolation Valves, Fire tender and fire- extinguisher |

OSHA makes reference to NFPA 86 under paragraph 1910.107, the law related to coating processes utilizing flammable or combustible liquids. NFPA 86 is therefore the minimum standard required by law, and should be applied in all processes falling under OSHA regulations. Also OSHA 1910.106 which is primarily based on NFPA 30 applies to the handling, storage, and use of flammable and combustible liquids with a flash point below 200°C. These standards along with IS standard were compared to those of the existing control measures in place and it was found that most of the measures were according to the above standards giving all necessary importance to fire safety.

3. 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 Kitchen:

The requirement for paint kitchen as per OSHA 1910.106/ NFPA 30 is same as that for paint storage area. However, as per OSHA 1926.66 there

are additional requirements such as areas are illuminated through glass panels or other transparent materials, only fixed lighting units shall be used as a source of illumination, Panels shall be so arranged that normal accumulations of residue on the exposed surface of the panel will not be raised to a dangerous temperature by radiation or conduction from the source of illumination. The organization has maintained all the necessary requirements as per this standard by providing fixed lighting units and suitable panels for accumulations of residue.

As per IS 9109:2000, all the requirements for paint kitchen are same as that of paint storage area except that there are two more additional requirements such as Flammable solvents such as thinner should not exceed boiling point. All lighting fittings and switches shall be of the enclosed type. It is observed that the paint shop personnel takes utmost care to monitor the boiling point of thinner such that it doesn't exceed the desired limit.

Rag/Tag Area:

According to OSHA 1910.106/ NFPA 30 Flammable liquids shall be kept in covered containers when not actually in use and where flammable or combustible liquids are used or handled, except in closed containers, means shall be provided to dispose promptly and safely of leakage or spills. Also as per IS 7969-1975, paint scrapings and paint-saturated rags and debris shall be removed daily from the premises and, preferably, destroyed by burning at a safe place. All these are very well followed by the organization as per the IS norms.

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. The electrostatic guns used in the paint booth of the

organization are well earthed and the booth has a static electricity disposer at the door.

Paint Baking Oven:

According to 29CFR 1910.107/NFPA 86 prior to the furnace heating system startup, provision shall be made for the removal of all flammable vapors and gases that have entered the heating chambers during the shutdown period, the regulators, relief valves and switches shall be vented to an approved location and heating elements must be securely fastened.

IS 9109:2000 states that

- Oven shall be constantly watched during the process. An excess temperature alarm shall be provided to attract attention of persons to manually control the situation.
- Safe operating temperature shall not be exceeded. An automatic control shall be provided to ensure against excessive temperature. Such a system shall be interlocked with a device to shut off the heating medium.

In the organization, the paint baking oven has an electrical panel with interlock system. The interlock system maintains the temperature of the oven. If the temperature goes higher than the actual temperature, it will cut off the supply the hot air from the PNG gas pipes and will reduce the temperature and thus preventing fire and explosion.

CO₂ Bank:

29CFR 1910.160 states

- Automatic detection equipment shall be approved, installed and maintained in accordance with 1910.164.
- At least one manual station is provided for discharge activation of each fixed extinguishing system.
- Automatic actuation of total flooding systems by means of an approved fire detection device installed and interconnected with a pre-discharge employee alarm system should be provided.
- Assure that the weight and pressure of refillable containers is checked at least semi-annually. If the container shows a loss in net content or weight of more than 5 percent, or a loss in pressure of more than 10 percent, it shall be subjected to maintenance.
- All fire protection systems must have pipes and fittings that are suitable for the expected temperature extremes with good corrosion resistance properties.

IS 15528: 2004 states that the extinguishing media used shall be carbon dioxide complying with the requirements of IS 15222.

As per the above requirements, the CO₂ bank operates as follows:

The areas are fitted with three smoke detectors. If there is smoke inside the area, at least two of the smoke detectors should send a signal to the electrical panel for the CO₂ flooding system to be activated. Once the signal reaches, the electrical panel sends signals to the pivot cylinders which in turn pressurize the CO₂ cylinders and through the pipes and discharge holes CO₂ gas is released and fire is extinguished. In case of small fires, pilot cylinders are kept at appropriate places along with sand buckets for extinguishing fire. The fire department periodically checks the CO₂ cylinders and keeps a track of the pressure inside them.

4. 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.

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