Hanover Risk Solutions

Paint Spray and Powder Coating Processes

Many manufactured products are finished by the application of paint to the surfaces. Paint serves to protect the object from the elements and improves the appearance at the same time. This report examines paint spray and powder coating systems, emphasizing the physical hazards involved, and the appropriate risk control measures to be taken. A discussion of health and safety hazards not related to fire and explosion is beyond the scope of this report.

Paint, in one form or another, has been used for the protection and beautification of finished products and structures for thousands of years. Most paints are formulated as mixtures of three basic components—resinous or resin-forming "binder," pigment, and a solvent– and are applied as a coating to various types of surfaces. The purpose of the coating may be decorative, protective, or functional.

In the past hundred years or so, a number of mechanical processes for the spray application of paint have been developed. The first of these processes, known as the conventional paint spray process, uses air under pressure to atomize the paint by forcing it through a spray gun nozzle at low pressure. Since the paint spray guns are designed to handle only liquids of low viscosity, most of the paints used are diluted with solvents. Since the 1930s, a number of other spray finishing processes have been developed to overcome some of the shortcomings of the conventional spray process, such as viscosity of the paint, amount of solvent overspray, and excessive evaporation loss. These painting processes include the hot spray, vapor spray, airless or high-pressure spray, and electrostatic spray processes. Of the four latter methods, the vapor spray process is rarely used.

The area where painting takes place is referred to as a spray area. Spray areas are locations where quantities of flammable or combustible vapors are present because of a spraying operation. They may be enclosed, unenclosed, or partially enclosed. Partially enclosed spray areas, such as spray hoods, are used in conjunction with ventilation systems. They are typically enclosed on three sides. Fresh air is drawn through the fourth side across the spray area and out through an exhaust systems. Spray booths are fully enclosed areas within a larger room that contains the paint spray operations. Spray booths are ventilated to remove hazardous concentrations of vapors through an exhaust system. They provide additional protection by enclosing the space where flammable vapors could be concentrated.

This report will cover the fire and explosion hazards of the commonly used spray

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processes and provide information on the control measures recommended for each process. In addition, the report will cover the powder application of finishes, as related to these processes.

While this report provides some basic information related to health hazards of paint application processes, a detailed analysis of the health hazards encountered is beyond the scope of this report. The risk control consultant or industrial hygienist should obtain a list of the materials used before visiting a risk, so that possible health hazards can be considered.

Paint Types

The three major paint types in use are water-based, oil-based, and powder paints. Water-based and oil-based paints contain a solvent for ease of dispersal. Dry powders, as used in the powder coating system, eliminate the solvent. The material is applied in a finely granulated, powder form, either to a heated surface or, as in the electrostatic spray process, to a cold surface that is then heated to form the smooth, finished coating. Powder coatings eliminate the problem related to the use of solvents and overspray, yet they do have their own inherent hazard because of the potential for a dust explosion.

Binders

Binders can be oils, such as alkyds, cellulosic, acrylics, vinyls, phenolics, epoxies, polyurethanes, silicones, and amino resins; or latexes, such as styrene-butadiene polyvinyl acetates and acrylics.

Pigments

Pigments are divided into inorganic, such as whites (e.g., titanium dioxide, lithopone, etc.); extender (i.e., fillers); inert; and supplemental pigments, such as calcium carbonate, clays, talcs, and silicas; inorganic colors (e.g., iron oxides, red lead, chrome yellows and oranges, zinc yellow, etc.), blacks, and metallics; and organic pigments, such as the insoluble azo pigments, acid azo pigments, and phthalocyanines.

Solvents

Solvents may be either water or a low-, medium-, or high-boiling point solvents, such as hydrocarbons, alcohols, ethers, ketones, esters, chlorinates, or nitrated solvents.

Processes

The conventional spray process is still widely used in industry, especially where there is a wide diversity of colors to be applied in a short span of time. Due to its inherent limitations, discussed below, it is gradually being replaced by the newer processes, such as hot spray, airless, and electrostatic spraying. The dual component and powder coating systems are specialized systems that can be incorporated within any of the four major spray processes.

The main uses of the hot spray, airless, and electrostatic spray processes are where high production, uniform coating, limited overspray, and reduced solvent pollution are desired. They have found wide usage in the finishing of automobile, truck, and trailer bodies, prefabricated homes, and automated or semi-automated paint spray operations. Increasingly, the airless method of paint application has found favor among large and small commercial paint contractors and among homeowners, in the case of small airless units.

Conventional Spray Process

Conventional spray guns use air pressure to atomize the paint by forcing it through a nozzle at low pressures of 60-70 psig (414-483 kPa) for industrial processing and as low as 40 psig (276 kpa) for commercial and home operations. The paint may be aerated before it leaves the nozzle, or it may be mixed and aerated in front of the nozzle depending on the type of paint and its application. Since the guns are designed to handle liquids of low viscosity, the paints are usually diluted with either water- or hydrocarbon-based solvents.

A major challenge of the conventional spray process, especially where large volumes of paint are prepared and used with hydrocarbon-based solvents, has been maintaining the paint at a constant viscosity. Batch mixing of these paints tends to cause inconsistency in the viscosity due to changing temperatures and solvent expansion. For example, paints thinned in the morning may be too thin later in the day due to increasing ambient temperatures. Another problem is that a fire and explosion hazard is created as the solvent is evaporated in the drying process. In addition, the air pressures required to atomize the thinned paint can cause considerable overspray of paint and solvents. This overspray is wasted by being deposited in the spray booth or exhausted to the atmosphere.

Hot Spray Process

In the hot spray process, the paint is heated and then discharged at lower atomizing air pressures, thereby resulting in less paint over-spray. Due to the lowered viscosity, heavier paints using smaller amounts of solvent may be used. With smaller amounts of solvent and reduced air pressures, heavier coats of paint can be applied with each pass of the spray gun. The drying time is shortened, since less solvent is required, and the application of the hot paint causes the solvent to vaporize faster.

The equipment used is similar to that used in conventional spray painting, except that the paint is heated to 140°F (60°C) to 180°F (82°C) to reduce its overall viscosity by one-third to one-fourth. The paint heater can be an electrical heater or a heat exchanger using hot water, steam, or other hot liquids or gases. Paint heaters are usually self-contained units composed of a heater, a pump, a paint-filtering system, and a supply tank.

Hot spray systems are mainly used where high-viscosity paints are required, where a heavy coat of paint is required per application, and where cost or other considerations do not require the switch to an airless spray system.

Airless (High Pressure) Spray Process

In an airless or high-pressure spraying process, the paint is atomized by forcing it through specially designed nozzles at high fluid pressures, normally between 1,500 and 2,500 psig (10,342 and 17,237 kPa). In some systems, the pressures may run as low as 200 psig (1,379 kpa) and, in others, as high as 5,000 psig (34,475 kpa). A heating system for the paint can be used to control viscosity, decrease the amount of solvent, and reduce the thickness of the applied film. Using a heater, the paint can be sprayed at lower hydraulic pressures, often as low as 200 psig (1,379 kpa). The equipment usually consists of an air-driven hydraulic pump, high-pressure paint hoses, and special spray guns.

This process produces very little turbulence or rebound of the paint particles and minimal overspray. The savings in paint and solvent can be considerable when compared to the cost of using conventional spray processes.

Electrostatic Paint Processes

The electrostatic spray process and the drip-deterring paint process were developed during the 1930s. Both processes rapidly found wide-spread use in the mass production of painted products, such as automobile and truck bodies and household products. The electrostatic spray process and dip deterring of paint process operate on the basic law of physics that non-like electrical charges attract each other and like electrical charges repel. In both processes, a transformer-rectifier unit is used to convert 240 volts AC to 85,000–130,000 volts AC. This higher voltage is then converted through half-wave rectification to 60,000–91,000 volts DC. Then, depending on the process, either the paint or the object to be painted is provided with a negative charge and the other (paint or object) is grounded. Thus, the paint, being fluid, will move either toward the object as in the electrostatic spray process, or away, as in the dip-deterring process.

Electrostatic Spray Process

In electrostatic spray painting, the paint can be atomized by air pressure to as low as 4–5 psig (28–35 kpa), or by the rapid rotation of bells or discs. When air pressure is used, the paint particles can be given the negative charge at the spray gun or by passing them adjacent to or through a grid held at high voltage. The paint particles are charged by the grid and thus propelled to the work that has an opposite electrical charge. If rotating bells or discs are used to atomize the paint, the particles are given the negative electrical charge at the edge of the bells or discs.

Either the spray guns or rotating bells or discs used may be fixed, with the work passing in front or around them, or they may be portable. The operation is the same for both. The portable guns are mainly used for small runs or differently shaped objects, or where mass production dictates the mixing of different products on the same line. Because the negatively charged paint particles are attracted to all parts of the oppositely charged object, all sides of the object receive a uniform coating of paint when the guns are located properly. There is also little overspray, resulting in substantial savings of paint and solvent.

Electrostatic Dip Process

The electrostatic process is reversed when objects are being dip-coated. The product, hung on work hooks attached to an overhead conveyor, is dipped in a paint dip tank or flow-coated, allowed to drain until the flow of paint has practically stopped, and then carried over a negatively-charged deterring grid, usually charged at about 85,000 volts DC. An electrical attractive force is established between the electrostatic grid and the grounded article. This causes the "drips" or "tears" on the article to be attracted to the grid and results in a more uniform coating of paint.

Dual Component Systems

Dual component systems are mainly used for the application of organic peroxides, urethanes (including foamed and liquid types), epoxies, and similar materials. In the modified version of the conventional spray process, the gun has two or more component lines, in addition to an air pressure hose. The dual component system can also be adapted to the hot-spray and airless paint processes. The components may be internally mixed in the gun, such as with foam-type materials, or blended externally, such as with the polyester and epoxy resin systems. The pressures used will vary with the type of process and system in use.

Dual component systems that use peroxides require special application equipment. The amount of peroxide used depends on the type and its end use. The peroxide delivery lines should be kept separate from all other delivery lines to reduce the possibility of fire and explosion.

Powder Coating Systems

"Powder dusting" is the oldest of the powder coating systems. An early example is the porcelainized finish found on sinks, bathtubs, washing machines, etc. In the process, the product is heated and then passed in front of a spray gun that flocks or dusts it. The product may or may not be returned to an oven to set the finish. The gun used usually has four or more controls to vary the amount of powder applied to the product.

"Fluidized bed process" is a method of expanding a powdered plastic material by passing an air stream through the material. The heated product is then lowered into the "bed" of material, withdrawn, and then reheated, if necessary, to produce the desired resulting film. The thickness of the final coat to be applied is dependent on the temperature of the product, particle size, and length of time the product remains in the "bed."

Electrostatic Powder Coating Processes

In the electrostatic powder coating process, which is gradually replacing the older powder coating process, the product to be coated does not have to be heated and, as in all electrostatic systems, the applied coating can be of uniform thickness regardless of the complexity of the shape of the product. In all of these processes, the product to be coated is given an opposite charge from the powder.

The "electrostatic fluidized bed" differs from the "fluidized bed process" in that the "bed" is charged. The product to be coated is passed through the "bed" while it is under constant aeration. The powder, in the form of a fine dust, settles on the charged product in a uniform coat. The length of time within the dust cloud determines the thickness of the coat. Some systems, such as the in-line cascading fluidized bed, use two parallel-fluidized beds, with a wall partly separating each "bed" from a central area. The powders from the two beds intermix, forming a very fine dust that completely encloses the product. The thickness of the coating is determined by the length of the tunnel and the length of time the product remains in the tunnel.

The curtain and tunnel coating systems also use electrostatics to attract the paint to the product to be coated. The curtain coater uses a porous conveyer belt passing in front of the product to be coated. The belt picks up the powder that is then blown past a wire, charging the particles of powder, onto the oppositely charged product. The powder-coating tunnel introduces the product to be coated into a tunnel containing powder under constant aeration. The length of time for the passage of the product will determine the thickness of the coating.

Drying Processes

In addition to open air drying, including the use of heat lamps, ovens that may be used in the drying process may consist of direct-fired or indirect-fired heating units burning gas or oil or may make use of electrical heating, either by the use of exposed electrical heaters or enclosed units, such as heating plates and lamps. These areas are referred to as "flash-off areas." The drying process may range from single-stage drying, to more complicated processes that involve two or more drying stages, depending on the type of painting process in use. Additionally:

- Flash-off areas that are heated above ambient temperatures should meet the requirements of NFPA 86, *Standard for Ovens and Furnaces*.
- The heating or drying process for flammable or explosive materials should be restricted to ovens that add sufficient ventilation to the drying process to keep the concentration of flammables below 25 percent of their lower flammable or explosive limits.
- Air circulation through these ovens must be distributed as uniformly as possible and with sufficient turbulence to insure that the flammable vapor concentration in all parts of the oven is safely below the lower explosive limit (LEL) at all times.
- Enclosed flash-off areas should be provided with an automatic fire protection system.

Fire and Explosion Hazards

The major physical hazards in any spray painting operation are fire and explosion. This arises from the materials used and the conditions of use. The following information covers some of the typical fire and explosion hazards related to each of the paint spraying processes.

Conventional Spray Process

With the exception of water-based paints, paint spraying processes use solvents that are highly flammable. The solvents include methanol, acetone, mineral spirits, styrene, methyl ethyl ketone (MEK), turpentine, toluene, xylene, and chlorinated hydrocarbons. With the exception of a few chlorinated hydrocarbons, most solvents have specific gravities equal to water, low flash points, and have an explosion potential in normal spray operation concentrations, by volume, in air.

Additionally, paint buildup from overspray and spillage in paint hoods, on filters, within the ventilation systems, and in the surrounding areas can be a source of fires and explosions. A spark from operating equipment, or other sources of ignition, can cause a flash of fire through these areas, causing extensive damage. Spontaneous ignition may occur if the area is not kept free of paint and clear of organic wastes (e.g., rags, cloths, etc). Spontaneous ignition may also occur if residues from two or more types of coatings are permitted to accumulate one on top of the other in the spray booth, exhaust duct, and filters.

Hot Spray Process

In addition to the fire and explosion hazards discussed above, the hot-spray process introduces the added factor of heat. The paint is heated by an electrical heater or a heat exchanger, using hot water, steam, or other hot liquids or gases. If there is a short in the electrical system, or if the wrong wiring is used, an explosion and fire may occur. Although there is less overspray with hot-spray processing, some solvent vapors will present a significant hazard at room temperature. Others, such as the chlorinated hydrocarbons, may not ignite at room temperatures, but can ignite at the temperatures used in the process (140°F [60°C] to 180°F [82°C]).

Airless Spraying

In addition to the hazards previously discussed, there is a potential to generate a static spark during airless spraying, which can initiate a fire or an explosion. Additionally, if a high-pressure hose, normally between 1,500 (10,342 kPa) and 2,500 psig (17,237 kPa), is cut or punctured, highly volatile and explosive vapors can be released into the area. This can set the stage for an explosion of the materials should an ignition source be present.

Electrostatic Paint Processes

The electrostatic spray process and, to a lesser extent, the dip process, introduce the possibility of a high-voltage electrical spark in an area of explosive vapors. The hazard mainly arises during the startup operation, especially after a changeover, when one color of paint or paint system is changed to another. During this period, the apparatus is thoroughly cleaned with solvent. If the solvent vapors are not removed by ventilation, or if spills are not cleaned up prior to the startup, an electrical spark may ignite the explosive vapors.

Dual Component Systems

The organic peroxides used in dual component systems are a high-hazard group of chemicals used as catalysts in the plastic and related industries. As a paint component, they should be considered as "potentially explosive chemicals" that can support combustion and can explode even though air is excluded from the process. Organic peroxides burn more rapidly than ordinary flammable liquids or combustible solids. An important factor that can accelerate the rate of decomposition of organic peroxides is heat. This may evolve as a slow and gradual increase in temperature, a very rapid and violent decomposition, or an explosion.

Other factors of concern are decomposition vapors, contamination, and liquids used to dilute the peroxide concentration. Some of the peroxides, on decomposing, will give off highly flammable gases and vapors, increasing the potential for a fire or explosion. Contamination with various materials, such as strong acids or bases, sulfur compounds, amines, accelerators, or reducing agents of any type, will markedly reduce the stability of organic peroxides. The physical separation of very sensitive organic peroxides from their diluents can concentrate the shock-sensitive organic peroxides.

Because of these hazards, many companies have switched to epoxy- or isocyanate-based dual component systems, which present a much lesser fire hazard.

Powder Coating Systems

While most of the fire and explosion hazards previously discussed apply to the powder coatings process as well, the primary hazard in this process is a dust explosion. This explosion hazard is increased in powdered coating processes when the powdered paint is dispersed in the air as a "fluidized" material or is sprayed onto the item being coated. Measurements have shown that the minimum explosive concentration of the powders used is approximately 0.02 oz./ft.^{3} (20 g/m^3) of air. When this value is exceeded, such as when the concentration of recirculated exhaust air has not been reduced to an acceptable safe level, an explosion may occur.

Other causes of fires and explosions are related to the process itself and to the drying and cleaning of finished products. If the temperature of the product to be coated exceeds the ignition temperature of the coating, a fire and/or an explosion can occur. Fires and explosions can also occur during the cleaning of products and during plant cleanup operations through the use of spray guns, which place solvents into airborne concentrations, rather than vacuum sweeping equipment.

Drying Processes

The main hazard that arises during the drying process is explosion. Explosions in the drying oven can occur when the automatic controls used to monitor gas- and oil-fired ovens fail to prevent a buildup of combustible gas concentrations.

Risk Control

The most important risk control considerations in paint spraying operations are the prevention of fire and explosion and control of health hazards, which is beyond the scope of this report. This may be accomplished by incorporating safety features into the paint spray system, segregating the paint spraying area, and training equipment operators.

The paint spraying areas should be designed, operated, and maintained in accordance with the requirements of NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, published by the National Fire Protection Association (NFPA). However, NFPA 33 does not provide information related to "hazards of toxicity or industrial health and hygiene," and such health hazards are beyond the scope of this report.

Conventional Spray Process

The basic fire protection measures for conventional spray process are also appropriate for all of the other paint processes.

Spray Areas

NFPA 33 provides a number of requirements for the construction of spray areas, including, but not limited to:

- Aluminum should not be used for structural support members or the walls or ceiling of an area, or in ventilation ductwork.
- Paint spraying operations should be located in an area specially designed for this purpose, protected with an approved system of automatic sprinklers, and separated from other areas by walls, floors, and ceilings having a minimum of a one-hour fire-resistance rating.
- Paint spraying operations located in assembly, educational, institutional, or residual occupancies, should be protected with an approved system of automatic sprinklers and separated from other areas by walls, floors, and ceilings having a minimum of a two-hour fire-resistance rating.
- Paint spray booths should be separated from other areas by at least 3 ft. (0.9 m). Additional separation requirements are necessary for open-spray areas, spray hoods, and spray rooms based on the degree of hazard present.

Electrical

- Lighting fixtures should be listed/approved for use in hazardous areas and so located to prevent accumulation of overspray. Lighting equipment should be effectively isolated from the spray area by glass panels or other transparent materials, should be made of non-combustible materials, and should be protected so that breakage will be unlikely.

- Electrical equipment and wiring located in spray areas should be designed, installed, and approved in accordance with the provisions of NFPA 70, *National Electrical Code*, based on the type of hazard present (i.e., Class I, Division I). See *Hazardous Location Classification System* on Hanover's Risk Solutions website for additional information on hazardous electrical locations.

Ventilation

- Mechanical ventilation should be provided for all spraying areas to remove flammable vapors, mists, or powders, in accordance with NFPA 33. Fans and other related equipment should be constructed of non-ferrous metals to reduce the hazards of fire and explosion.
- The paint spraying equipment and the ventilation system should be properly maintained.

Operations

- All paint spraying and surrounding areas should be kept free of the accumulation of deposits of combustible residues. Floor runners and similar coverings should be changed at least daily to prevent the buildup of combustible residues.
- The storage and handling of flammable and combustible liquids should be in accordance with NFPA 30, *Flammable and Combustible Liquids Code,* as well as applicable federal, state, and local regulations.
- "No Smoking" signs should be installed in all areas where flammable liquids and combustible dusts are used.

Protection

- Paint spraying areas should be protected by an automatic suppression system, such as automatic sprinklers, carbon dioxide, dry chemical, or clean agent systems.
- Sprinkler heads in spray areas should be protected from overspray by either location or covering the head. Sprinkler heads may be covered with a "cellophane bag having a thickness of 0.08 mm (0.003 in) or less" or by thin paper bags. Such protective coverings should be "replaced frequently so that heavy deposits of residue do not accumulate."
- Fire protection systems in continuous spray operations should be interlocked with the spray process, so that ion activation of the system, the spray process, is stopped and associated facility alarms are initiated.

Hot Spray Process

Risk control measures, in addition to the previous controls, for the hot spray processes include:

- Paint heaters should be provided with thermostatic controls and a temperature gauge.
- The paint container, heating jacket, and the pump discharge should be provided with pressure-relief valves.
- Electric heaters should be listed/approved for the specific location in which they are used.
- Heaters should not be located in the spray booths, nor in any other location subject to the accumulation of deposits of combustible residue.
- If agitators are used, they should be driven by compressed air, water, low-pressure steam, or electricity. If electrically driven, the motor should conform to the requirements of the NFPA 70.
- Hose lines should be designed for the pressures and temperatures used in the hot spray process.

Airless (High Pressure) Spray Process

The hazard of airless spray process is related to the high pressure used. The following control measures, in addition to the controls for conventional spray processes, should be considered for both fixed- and hand-spraying equipment:

- Pumps, tanks, paint hoses, fittings, paint guns, and nozzles should be designed for the pressures required in the operation.
- The pressure pump should be designed to stop the pump if the discharge pressure exceeds the safe operating pressure of the system.
- High-pressure hoses should be designed for the pressures required, periodically inspected, and properly maintained. The hose should not be kinked or bent in less than the recommended radius stated by the manufacturer.
- Hoses showing material deterioration, signs of leakage, or weakness in the couplings should be withdrawn from service and repaired or discarded.
- Airless high-pressure spray guns and the conductive object being sprayed should be electrically bonded together or connected to a common ground.
- The spray gun should incorporate a safety diffuser to reduce the velocity and impact of the paint stream. An automatic check valve or lock should be incorporated in the gun to prevent a high-pressure jet of paint from being released if the gun is triggered while the nozzle is removed.
- The spray nozzle should not be removed from the spray gun, nor disconnected from the paint hose, without first releasing the fluid pressure. The spray gun should not be pointed at any part of the body.
- Approved safety glasses or goggles and approved gloves should be worn while in the spraying area.
- Operators should be trained in the hazards of high-pressure or airless spray process, as well as procedures to follow in the event of an accident.
- Safety warning information is recommended to be affixed or applied to the paint pump. The information should include:

Warning–High-Pressure Device. This equipment can cause serious injury. Do not alter equipment. Do not grab front end of gun or permit any part of the body to come in close proximity to the face of the spray cap or tip. Use only conductive airless spray hose. When gun is not in use, always set safety lock in closed position. Read Instruction Manual carefully before operation. Maximum working pressure of spray gun is [_______] psi ([_______] kPa).

Electrostatic Paint Process

The introduction of high-voltage electricity into a volatile and explosive atmosphere warrants, in addition to the controls for conventional spray processes, the following control measures:

- Transformers, power packs, control apparatus, and all other electrical portions of the equipment, with the exception of high-voltage grids and electrostatic atomizing heads and their connections, should be located outside the spraying area, unless otherwise specified.
- The electrostatic apparatus should be equipped with automatic controls to disconnect the power supply to the high-voltage transformer and to signal the operator if the ventilation equipment fails, the conveyor or product line stops, or if an excessive voltage drop is detected.
- High voltage leads to electrodes, and electrostatic atomizing heads should be effectively and permanently supported on suitable insulators and should be effectively guarded against accidental contact or grounding. Electrodes and insulators should be kept clean and dry.
- An automatic means should be provided for grounding and discharging any accumulated residual charge on the electrode assembly or the secondary circuit of the high-voltage transformer when the transformer primary is disconnected from the source of supply.

- The space maintained between the articles being painted and electrodes or atomizing heads should be at least twice the sparking distance. (A sign should be posted, designating the sparking distance for each installation.) The articles should be supported on conveyors that are arranged to maintain the safe distance at all times.
- The spraying area should be adequately ventilated to minimize the possibility of explosion, fire, and health hazards.
- Adequate booths, fencing, railings, or guards should be placed about the equipment for the protection of personnel. These should be of conducting material and adequately bonded and grounded. They should be at least 5 ft. (1.5 m) from the processing equipment.
- If electrically-conductive paint is used, the support unit and tank lines for the paint tank should be barricaded so that personnel will not be exposed to high voltage.
- Employees should not be allowed to work on the electrostatic equipment while the current is on. Fail-safe photoelectric or body capacitance safety controls, or their equivalent, should be installed so that the power supply will shut off if a person approaches the equipment while it is operating.
- A red signal warning lamp should be conspicuously mounted on the spray booth to indicate when the high voltage is on.

Electrostatic Hand Spraying

The use of electrostatic hand spraying equipment requires that, in addition to the controls for conventional spray processes, the following control measures be used:

- Electrostatic hand spray equipment should be of the listed/approved type and be designed to be intrinsically safe and to not produce a spark of sufficient intensity to ignite vapor-air mixtures, nor result in appreciable shock hazard on coming into contact with a grounded object.
- The electrostatically charged, exposed elements of the spray gun should be designed so they can only be energized by the switch that also controls the paint supply.
- The handle of the spray gun should be electrically connected to ground, to prevent a buildup of static charge on the operator's body. Additionally, electrically-conductive objects in the spraying area, including paint containers and wash cans, should be adequately bonded and grounded and should be posted with warning signs indicating the necessity for grounding.
- The electrostatic hand spraying equipment should be designed so the maximum surface temperature in the spraying area will not exceed 150°F (66°C) under any conditions.
- The spraying area should be adequately ventilated to insure safe conditions.
- The electrostatic apparatus should be equipped with automatic controls to disconnect the power supply to the high-voltage transformer and to signal the operator in the event of failure or stoppage of the ventilation equipment or occurrence of a ground between the high-voltage transformer and the spray gun.
- Warning signs should be posted prohibiting smoking or the carrying of lighters, matches, or other sources of ignition into the spraying area.
- The electrical power supply should be disconnected and "locked out" before repair work is done on the electrostatic equipment.

Dual Component Systems

The use of chemically unstable chemicals, such as organic peroxides, in dual component systems requires, in addition to the controls for conventional spray processes, the following control measures:

- The use of organic peroxides and other dual component coatings during spraying operations should be conducted in listed/approved spray booths.

- To prevent the contamination of organic peroxide initiators with any foreign substance, extreme care should be exercised at all times in their handling and use.
- Only spray guns and other related equipment, specifically manufactured for use with organic peroxides, should be used.
- Separate pressure vessels and inserts that are specifically designed for the type of application should be used, both for the resin and for the organic peroxides. In no event should these be interchanged.
- Stainless steel, polyethylene, or other chemically non-reactive materials should be used for the construction of the organic peroxide pressure tank inserts.
- Since the mixing of any dusts or overspray residues, which may result from the sanding or spraying of finished materials containing organic peroxides, with other materials may result in a spontaneous fire or explosion, extreme care should be exercised at all times.
- All spilled peroxides should be promptly removed so that there are no residues remaining after the cleanup. The spilled materials should be removed by using a non-combustible absorbent and then promptly disposing of the absorbent.

Storage and Handling of Organic Peroxides

Organic peroxides should be stored in a temperature-controlled, detached building, apart from all finished materials. Only the minimum daily requirements of organic peroxides should be brought to the processing area. Any material left over at the spraying station at the end of a day's operation should be disposed of carefully.

- Organic peroxides should be kept away from all sources of heat, including steam pipes, radiators, open flames or sparks, and solar radiation.
- Extreme care should be exercised in the handling of organic peroxides to avoid any possibility of the occurrence of shock and friction, which can cause them to decompose and to react violently.
- Organic peroxides should not be mixed directly with accelerators or promoters because this may result in a violent decomposition or explosion.
- All smoking should be prohibited in the areas where organic peroxides may be present. "No Smoking" signs should be prominently displayed in these areas.
- Only non-sparking tools should be used in any area where organic peroxides are stored, mixed, or applied.
- Only specifically trained personnel should be permitted to work with these materials.

Powder Coating Systems

In addition to the risk control measures previously discussed for conventional spray processes, the following measures are specifically recommended for powder coating systems:

- To prevent the accumulation of powder and to facilitate cleaning, the enclosures used for conducting coating operations should be completely enclosed, be of non-combustible construction with smooth surfaces, and be properly ventilated. All areas including horizontal surfaces, such as ledges, beams, pipes, hoods, and booth floors, should be periodically cleaned to prevent the accumulation of powder. The surfaces should be cleaned with vacuum sweeping equipment of a type approved for use in hazardous locations. This will negate the scattering of the powder or the creation of powder clouds.
- Coating operations may be conducted in adequately ventilated spray booths that are specifically designed to meet the requirements for enclosures in which combustible dust operations are conducted. Enclosed, adequately ventilated containers, such as tanks and bins constructed of non-combustible materials, can also be used for powder coating operations.

- All metal parts of spray booths, exhaust ducts, and piping systems conveying aerated solids should be properly bonded and grounded, in accordance with the requirements of NFPA 77, *Recommended Practice on Static Electricity*, including powder transport, application, and recovery equipment.
- The temperature of the part being coated should never exceed the ignition temperature of the powder.
- All enclosures of a powder coating operation, such as booths and recovery enclosures, which are effectively "tight" enclosures, should be provided with adequate explosion venting.
- All non-deposited, air-suspended powders should be safely removed from the operation, via exhaust ducts, to a powder recovery system. The rate of exhaust should be based on the compositions, particle size, and density of the powders in use.
- Automated powder coating operations should be provided with listed optical flame detection, installed and supervised in accordance with NFPA 72, *National Fire Alarm and Signaling Code*, which on flame detection will shut down the powder coating system, including the ventilation system, conveyers, and power to the high-voltage elements in the spray area.
- The exhausted air from the recovery system of a powder operation should not be used as recirculated or reconditioned air for the input air for that operation unless the particulate composition of the exhaust air has been returned to an acceptable safe level for that use.
- All recirculating air systems should be equipped with a system that continuously monitors the exhausted air. These systems should be designed to signal the operator, as well as to shut down the operation, in the event the particle-removal equipment fails to maintain the air in the system below the acceptable safe level.

Electrostatic and Fluidized Powder Coating

The following are additional risk control measures for powder coating systems involving electrostatic fixed and hand-held equipment and for fluidized beds:

- Electric, hand-powder coating equipment should be designed not to produce a spark of sufficient intensity to ignite any powder-air mixtures likely to be encountered.
- Electrostatic fluidized beds and associated equipment should be of approved types.
- High-voltage circuits should be designed so that any discharge produced when the charging electrodes of the bed are approached, or contacted by a grounded object, is not of sufficient intensity to ignite any powder-air mixture likely to be encountered, nor to result in an appreciable shock hazard.
- The transformers, powder packs, control apparatus, and all other electrical equipment, with the exception of the charging electrodes and their connections to the power supply, should be located outside of the powder coating area (unless of a type specified by the NFPA 70 for use in hazardous operations).
- All electrically conductive objects within the powder coating area should be adequately bonded and grounded. In addition, the powder coating equipment should carry a prominent, permanently installed warning regarding the necessity for grounding these objects.
- All objects being coated should be maintained in electrical contact with the conveyor or other support equipment in order to ensure proper grounding. Hangers should be regularly cleaned to ensure effective contact, and areas of contact should not be composed of sharp points or knife-edges, wherever possible.

- The electrical equipment should be interlocked with the ventilation system so that the equipment cannot be operated unless the ventilating fans are in operation.

Drying Processes

All drying and curing equipment used in conjunction with the spray application of flammable and combustible coatings should conform to the requirements of NFPA 86, *Standard for Ovens and Furnaces*, or Chapter 21 of the *International Fire Code* (IFC), published by the International Codes Council (ICC). Areas used for spraying operations should not be used alternately as a drying area if the arrangement will cause a substantial increase in the surface temperature of that area. The susceptibility to spontaneous heating and ignition of any overspray residue may be increased at temperatures above normal. Drying and curing heating systems that may have open flames or may produce sparks should not be installed in a spraying area. These systems may be installed next to the spray area if equipped with an interlocked ventilating system that is arranged to:

- Thoroughly ventilate the drying area before the heating system can be started;
- Maintain a safe atmosphere at any source of ignition;
- Automatically shut down the heating system in the event of failure of the ventilating system.
- Enclosed spray areas should be equipped with temperature monitoring and controls that will automatically shut off the drying apparatus if the air temperature in the spray area exceeds 200°F (93°C).

Automobile Refinishing

Automobile-refinishing spray booths or enclosures, otherwise installed and maintained in full conformity with nationally recognized standards for spray booths and drying apparatus, may alternatively be used for drying with portable, electrical infrared-drying apparatus, but only when conforming with the following:

- The interior of spray enclosures, especially the floors, is kept free of overspray deposits.
- During drying operations, all drying apparatus and any electrical connections and wiring thereto are not located within the spray enclosure nor in any other location where spray residue may be deposited thereon.
- Only equipment of a type approved for Class I, Division 2 locations is located within 18 in. (45.7 cm) of the floor level.
- All metallic parts of drying apparatus are properly bonded and grounded.
- A warning sign is prominently located and permanently attached to the drying apparatus, indicating that the ventilation is maintained during the drying period and that spraying should not be conducted in the vicinity.
- All spraying apparatus, drying apparatus, and ventilating system of spray enclosure is equipped with suitable interlocks arranged so that:
    1. Spray apparatus cannot be operated while drying apparatus is within the spray enclosure.
    2. The spray enclosure is purged of spray vapors for a period of not less than three minutes before drying apparatus can be energized.
    3. The ventilating system maintains a safe atmosphere within the enclosure during the drying process.
    4. The drying apparatus automatically shuts off in the event of failure of the ventilating system.

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