4.2.2.14 Surface Coating Of Plastic Parts For Business Machines

4.2.2.14.1 General[1-2]

Surface coating of plastic parts for business machines is defined as the process of applying coatings to plastic business machine parts to improve the appearance of the parts, to protect the parts from physical or chemical stress, and/or to attenuate electromagnetic interference/radio frequency interference (EMI/RFI) that would otherwise pass through plastic housings. Plastic parts for business machines are synthetic polymers formed into panels, housings, bases, covers, or other business machine components. The business machines category includes items such as typewriters, electronic computing devices, calculating and accounting machines, telephone and telegraph equipment, photocopiers, and miscellaneous office machines.

The process of applying an exterior coating to a plastic part can include surface preparation, spray coating, and curing, with each step possibly being repeated several times. Surface preparation may involve merely wiping off the surface, or it could involve sanding and puttying to smooth the surface. The plastic parts are placed on racks or trays, or are hung on racks or hooks from an overhead conveyor track for transport among spray booths, flashoff areas, and ovens. Coatings are sprayed onto parts in partially enclosed booths. An induced air flow is maintained through the booths to remove overspray and to keep solvent concentrations in the room air at safe levels. Although low-temperature bake ovens (60°C [140°F] or less) are often used to speed up the curing process, coatings also may be partially or completely cured at room temperature.

Dry filters or water curtains (in water wash spray booths) are used to remove overspray particles from the booth exhaust. In waterwash spray booths, most of the insoluble material is collected as sludge, but some of this material is dispersed in the water along with the soluble overspray components. Figure 4.2.2.14-1 depicts a typical dry filter spray booth, and Figure 4.2.2.14-2 depicts a typical water wash spray booth.

Many surface coating plants have only 1 manually operated spray gun per spray booth, and they interchange spray guns according to what type of coating is to be applied to the plastic parts. However, some larger surface coating plants operate several spray guns (manual or robotic) per spray booth, because coating a large volume of similar parts on conveyor coating lines makes production more efficient.

Spray coating systems commonly used in this industry fall into 3 categories, 3-coat, 2-coat, and single-coat. The 3-coat system is the most common, applying a prime coat, a color or base coat, and a texture coat. Typical dry film thickness for the 3-coat system ranges from 1 to 3 mils for the prime coat, 1 to 2 mils for the color coat, and 1 to 5 mils for the texture coat. Figure 4.2.2.14-3 depicts a typical conveyorized coating line using the 3-coat system. The conveyor line consists of 3 separate spray booths, each followed by a flashoff (or drying) area, all of which is followed by a curing oven. A 2-coat system applies a color or base coat, then a texture coat. Typical dry film thickness for the 2-coat system is 2 mils for the color (or base) coat, and 2 to 5 mils for the texture coat. The rarely used single-coat system applies only a thin color coat, either to protect the plastic substrate or to improve color matching between parts whose color and texture are molded in. Less coating solids are applied with the single-coat system than with the other systems. The dry film thickness applied for the single-coat system depends on the function of the coating. If protective properties are desired, the dry film thickness must be at least 1 mil (0.001 inches). For purposes of

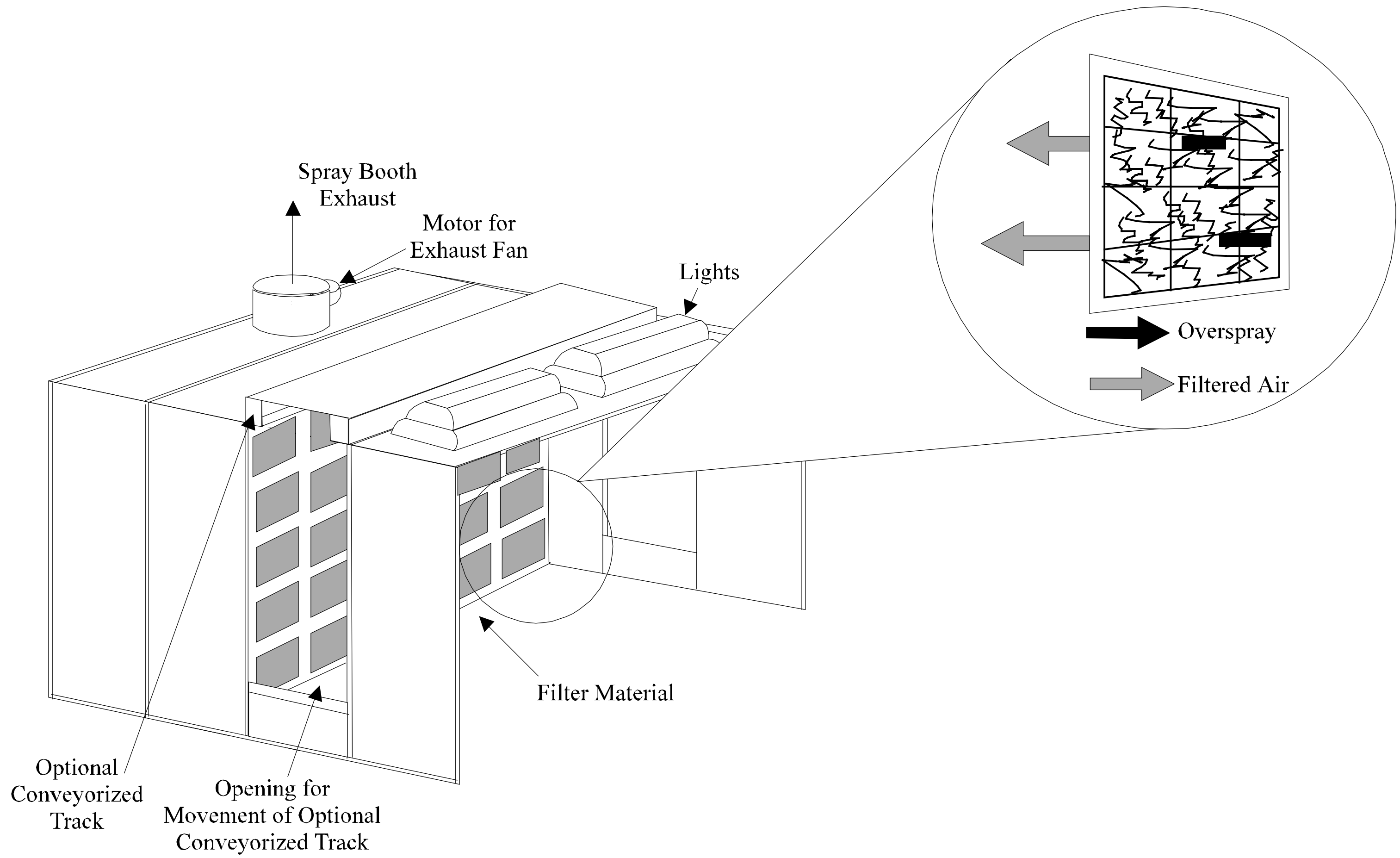

Figure 4.2.2.14-1. Typical dry filter spray booth. [3-4]

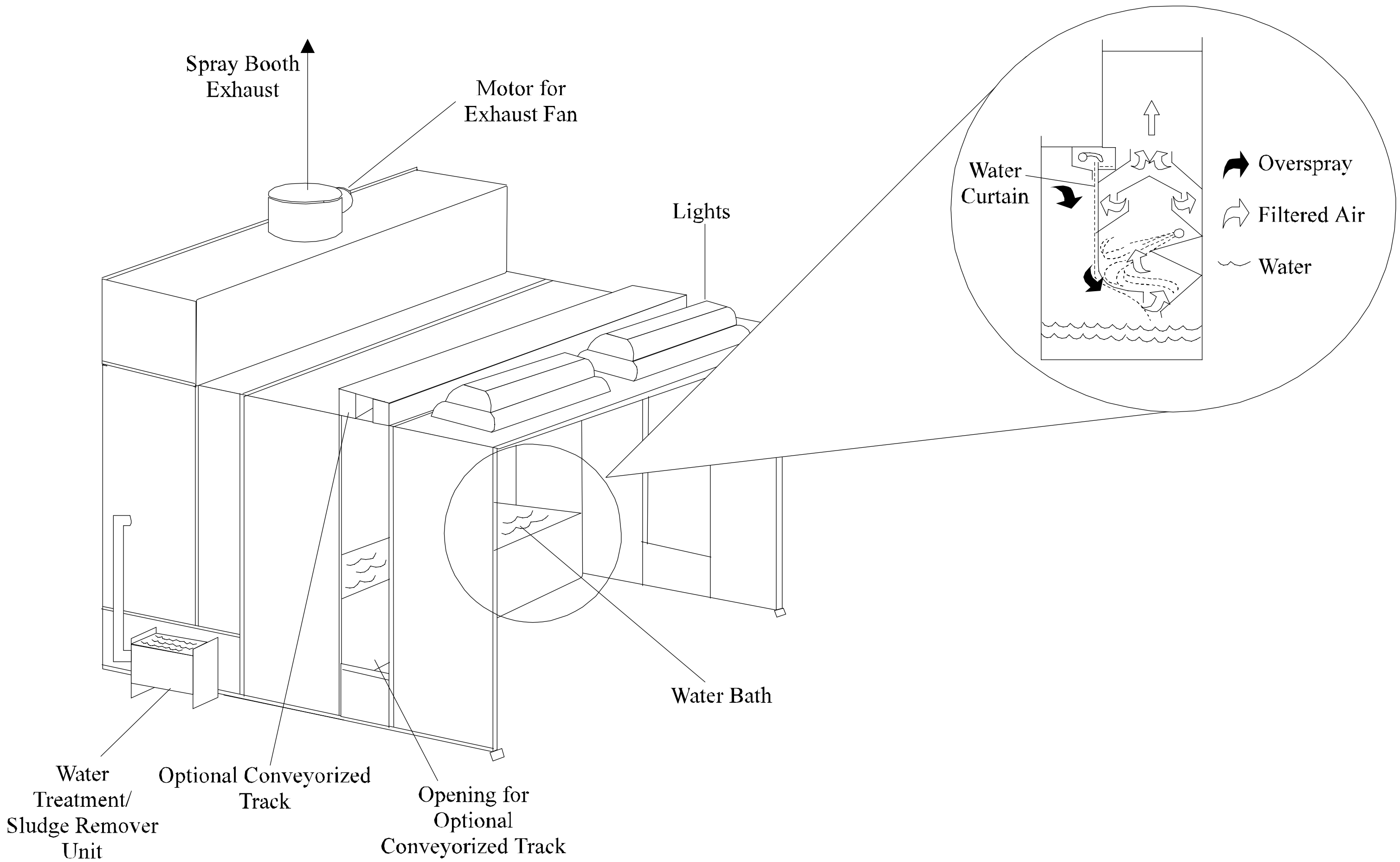

Figure 4.2.2.14-2. Typical water wash spray booth.[3]

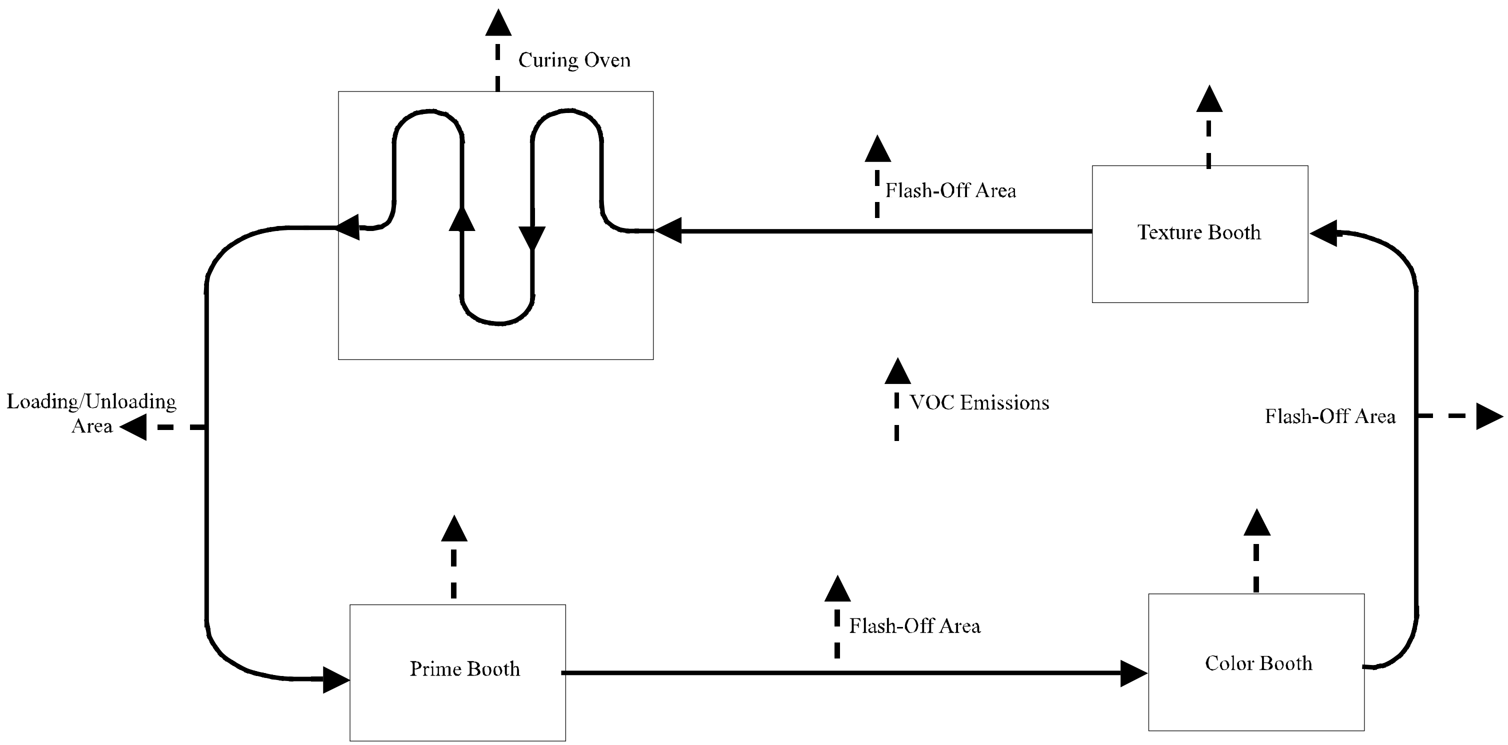

Figure 4.2.2.14-3. Typical conveyor line for 3-coat system.

color matching among parts having molded-in color and texture, a dry film thickness of 0.5 mils or less is needed to avoid masking the molded-in texture. The process of applying 0.5 mils of coating or less for color matching is commonly known as "fog coating", "mist coating", or "uniforming".

The 3 basic spray methods used in this industry to apply decorative/exterior coatings are air-atomized spray, air-assisted airless spray, and electrostatic air spray. Air-atomized spray is the most widely used coating technique for plastic business machine parts. Air-assisted airless spray is growing in popularity but is still not frequently found. Electrostatic air spray is rarely used, because plastic parts are not conductive. It has been used to coat parts that have been either treated with a conductive sensitizer or plated with a thin film of metal.

Air-atomized spray coating uses compressed air, which may be heated and filtered, to atomize the coating and to direct the spray. Air-atomized spray equipment is compatible with all coatings commonly found on plastic parts for business machines.

Air-assisted airless spray is a variation of airless spray, a spray technique used in other industries. In airless spray coating, the coating is atomized without air by forcing the liquid coating through specially designed nozzles, usually at pressures of 7 to 21 megapascals (MPa) (1,000 to 3,000 pounds per square inch [psi]). Air-assisted airless spray atomizes the coating by the same mechanism as airless spray, but at lower fluid pressures (under 7 MPa [1,000 psi]). After atomizing, air is then used to atomize the coating further and to help shape the spray pattern, reducing overspray to levels lower than those achieved with airless atomization alone. Figure 4.2.2.14-4 depicts a typical air-assisted airless spray gun. Air-assisted airless spray has been used to apply prime and color coats but not texture coats, because the larger size of the sprayed coating droplet (relative to that achieved by conventional air atomized spray) makes it difficult to achieve the desired surface finish quality for a texture coat. A touch-up coating step with air atomized equipment is sometimes necessary to apply color to recessed and louvered areas missed by air-assisted airless spray.

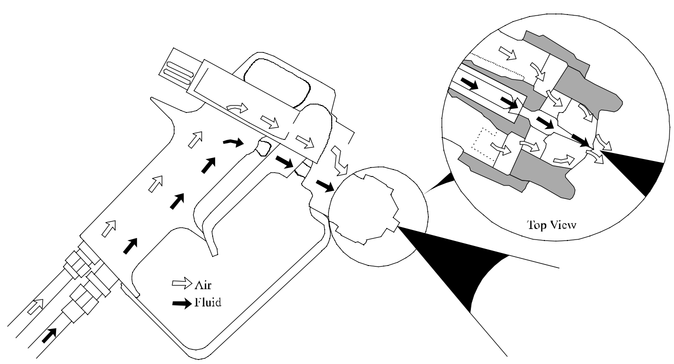

Figure 4.2.2.14-4. Typical air-assisted airless spray gun.[5]

In electrostatic air spray, the coating is usually charged electrically, and the parts being coated are grounded to create an electric potential between the coating and the parts. The atomized coating is attracted to the part by electrostatic force. Because plastic is an insulator, it is necessary to provide a conductive surface that can bleed off the electrical charge to maintain the ground potential of the part as the charged coating particles accumulate on the surfaces. Electrostatic air spray has been demonstrated for application of prime and color coats and has been used to apply texture coats, but this technique does not function well with the large-size particles generated for the texture coat, and it offers no substantial improvement over air-atomized spray for texture coating. A touch-up coating step with air-atomized spray is sometimes necessary to apply color and texture to recessed and louvered areas missed by electrostatic spray.

The coatings used for decorative/exterior coats are generally solvent-based and waterborne coatings. Solvents used include toluene, methyl ethyl ketone, methylene chloride, xylene, acetone, and isopropanol. Typically, organic solvent-based coatings used for decorative/exterior coats are 2 types of 2-component catalyzed urethanes. The solids contents of these coatings are from 30 to 35 volume percent (low solids) and 40 to 54 volume percent (medium solids) at the spray gun (i. e., at the point of application, or as applied). Waterborne decorative/exterior coatings typically contain no more than 37 volume percent solids at the gun. Other decorative/exterior coatings being used by the industry include solvent-based high solids coatings (i. e., equal to or greater than 60 volume percent solids) and 1-component low solids and medium solids coatings.

The application of an EMI/RFI shielding coat is done in a variety of ways. About 45 percent of EMI/RFI shielding applied to plastic parts is done by zinc-arc spraying, a process that does not emit volatile organic compounds (VOC). About 45 percent is done using organic solvent-based and waterborne metal-filled coatings, and the remaining EMI/RFI shielding is achieved by a variety of techniques involving electroless plating, and vacuum metallizing or sputtering (defined below), and use of conductive plastics, and metal inserts.

Zinc-arc spraying is a 2-step process in which the plastic surface (usually the interior of a housing) is first roughened by sanding or grit blasting and then sprayed with molten zinc. Grit blasting and zinc-arc spraying are performed in separate booths specifically equipped for those activities. Both the surface preparation and the zinc-arc spraying steps currently are performed manually, but robot systems have recently become available. Zinc-arc spraying requires a spray booth, a special spray gun, pressurized air, and zinc wire. The zinc-arc spray gun mechanically feeds 2 zinc wires into the tip of the spray gun, where they are melted by an electric arc. A high pressure air nozzle blows the molten zinc particles onto the surface of the plastic part. The coating thickness usually ranges from 1 to 4 mils, depending on product requirements.

Conductive coatings can be applied with most conventional spray equipment used to apply exterior coatings. Conductive coatings are usually applied manually with air spray guns, although air-assisted airless spray guns are sometimes used. Electrostatic spray methods cannot be used because of the high conductivity of EMI/RFI shielding coatings.

Organic solvent-based conductive coatings contain particles of nickel, silver, copper, or graphite, in either an acrylic or urethane resin. Nickel-filled acrylic coatings are the most frequently used, because of their shielding ability and their lower cost. Nickel-filled acrylics and urethanes contain from 15 to 25 volume percent solids at the gun. Waterborne nickel-filled acrylics with between 25 and 34 volume percent solids at the gun (approximately 50 to 60 volume percent solids, minus water) are less frequently used than are organic solvent-based conductive coatings.

The application of a conductive coating usually involves 3 steps: surface preparation, coating application, and curing. Although the first step can be eliminated if parts are kept free of mold-release agents and dirt, part surfaces are usually cleaned by wiping with organic solvents or detergent solutions and then roughened by light sanding. Coatings are usually applied to the interior surface of plastic housings, at a dry film thickness of 1 to 3 mils. Most conductive coatings can be cured at room temperature, but some must be baked in an oven.

Electroless plating is a dip process in which a film of metal is deposited in aqueous solution onto all exposed surfaces of the part. In the case of plastic business machine housings, both sides of a housing are coated. No VOC emissions are associated with the plating process itself. However, coatings applied before the plating step, so that only selected areas of the parts are plated, may emit VOCs. Waste water treatment may be necessary to treat the spent plating chemicals.

Vacuum metallizing and sputtering are similar techniques in which a thin film of metal (usually aluminum) is deposited from the vapor phase onto the plastic part. Although no VOC emissions occur during the actual metallizing process, prime coats often applied to ensure good adhesion and top coats to protect the metal film may both emit VOCs.

Conductive plastics are thermoplastic resins that contain conductive flakes or fibers of materials such as aluminum, steel, metallized glass, or carbon. Resin types currently available with conductive fillers include acrylonitrile butadiene styrene, acrylonitrile butadiene styrene/polycarbonate blends, polyphenylene oxide, nylon 6/6, polyvinyl chloride, and polybutyl terephthalate. The conductivity, and therefore the EMI/RFI shielding effectiveness, of these materials relies on contact or near-contact between the conductive particles within the resin matrix. Conductive plastic parts usually are formed by straight injection molding. Structural foam injection molding can reduce the EMI/RFI shield effectiveness of these materials because air pockets in the foam separate the conductive particles.

4.2.2.14.2 Emissions And Controls

The major pollutants from surface coating of plastic parts for business machines are VOC emissions from evaporation of organic solvents in the coatings used, and from reaction byproducts when the coatings cure. VOC sources include spray booth(s), flashoff area(s), and oven(s) or drying area(s). The relative contribution of each to total VOC emissions vary from plant to plant, but for an average coating operation, about 80 percent is emitted from the spray booth(s), 10 percent from the flashoff area(s), and 10 percent from the oven(s) or drying area(s).

Factors affecting the quantity of VOC emitted are the VOC content of the coatings applied, the solids content of coatings as applied, film build (thickness of the applied coating), and the transfer efficiency (TE) of the application equipment. To determine of VOC emissions when waterborne coatings are used, it is necessary to know the amounts of VOC, water, and solids in the coatings.

The TE is the fraction of the solids sprayed that remains on a part. TE varies with application technique and with type of coating applied. Table 4.2.2.14-1 presents typical TE values for various application methods.

Volatile organic compound emissions can be reduced by using low VOC content coatings (i. e., high solids or waterborne coatings), using surface finishing techniques that do not emit VOC, improving TE, and/or adding controls. Lower VOC content decorative/exterior coatings include high solids content (i. e., at least 60 volume percent solids at the spray gun), 2-component catalyzed urethane coatings, and waterborne coatings (i. e., 37 volume percent solids and 12.6 volume percent VOC at the spray gun). Both of these types of exterior/decorative coatings contain less VOC than conventional urethane coatings, which are typically 32 volume percent solids at the gun. Lower VOC content EMI/RFI shielding coatings include organic solvent-based acrylic or urethane conductive coatings containing at least 25 volume percent solids at the spray gun and waterborne conductive coatings containing 30 to 34 volume percent solids at the gun. Use of lower VOC content coatings reduces emissions of VOCs both by reducing the volume of coating needed to cover the part(s) and by reducing the amount of VOC in the coatings that are sprayed.

The major technique which provides an attractive exterior/decorative finish on plastic parts for business machines without emitting VOCs is the use of molded-in color and texture. VOC-free techniques for EMI/RFI shielding include zinc-arc spraying, electroless plating, the use of conductive plastics or metal inserts, and in some cases, vacuum metallizing and sputtering.

Table 4.2.2.14-1. TRANSFER EFFICIENCIES[a]

Application Methods	Transfer Efficiency (%)	Type Of Coating
Air-atomized spray	25	Prime, color, texture, touchup, and fog coats
Air-assisted airless spray	40	Prime, color coats
Electrostatic air spray	40	Prime, color coats

[a] As noted in the promulgated standards, values are presented solely to aid in determining compliance with the standards and may not reflect actual TE at a given plant. For this reason, table should be used with caution for estimating VOC emissions from any new facility. For a more exact estimate of emissions, the actual TE from specific coating operations at a given plant should be used. Reference 1.

Transfer efficiency can be improved by using air-assisted airless or electrostatic spray equipment, which are more efficient than the common application technique (air atomized). More efficient equipment can reduce VOC emissions by as much as 37 percent over conventional air atomized spray equipment, through reducing the amount of coating that must be sprayed to achieve a given film thickness.

Add-on controls applied to VOC emissions in other surface coating industries include thermal and catalytic incinerators, carbon adsorbers, and condensers. However, these control technologies have not been used in the surface coating of plastic parts because the large volume of exhaust air and the low concentrations of VOC in the exhaust reduce their efficiency.

The operating parameters in Tables 4.2.2.14-2 and 4.2.2.14-3 and the emissions factors in Tables 4.2.2.14-4 and 4.2.2.14-5 are representative of conditions at existing plants with similar operating characteristics. The 3 general sizes of surface coating plants presented in these tables (small, medium, and large) are given to assist in making a general estimate of VOC emissions. However, each plant has its own combination of coating formulations, application equipment, and operating parameters. Thus, it is recommended that, whenever possible, plant-specific values be obtained for all variables when calculating emission estimates.

A material balance may be used to provide a more accurate estimate of VOC emissions from the surface coating of plastic parts for business machines. An emissions estimate can be calculated using coating composition data (as determined by EPA Reference Method 24), and data on coating and solvent quantities used in a given time period by a surface coating operation. Using this approach, emissions are calculated as follows:

$$M_T = \sum_{i=1}^{n} L_{ci} \, D_{ci} \, W_{oi}$$

where:

M_T = total mass of VOC emitted (kg)
L_c = volume of each coating consumed, as sprayed (L)
D_c = density of each coating consumed, as sprayed (kg/L)
W_o = the proportion of VOC in each coating, as sprayed (including dilution solvent added at plant) (weight fraction)
n = number of coatings applied

Table 4.2.2.14-2 (Metric Units). REPRESENTATIVE PARAMETERS FOR SURFACE COATING OPERATIONS TO APPLY DECORATIVE/EXTERIOR COATINGS[a]

Plant Size	Operating Schedule (hr/yr)	Number Of Spray Booths: Dry Filter	Number Of Spray Booths: Water Wash	Surface Area Coated/yr (m^2 Of Plastic)	Coating Option/Control Techniques	Coating Sprayed (L/yr)
Small	4,000	2	0	9,711	Baseline coating mix[b]	16,077[c]
					Low solids SB coating[d]	18,500[c]
					Medium solids SB coating[e]	11,840[c]
					High solids SB coating[f]	9,867[c]/6,167[g]
					WB coating[h]	16,000[c]
Medium	4,000	5[i]	0	77,743	Baseline coating mix[b]	128,704[c]
					Low solids SB coating[d]	148,100[c]
					Medium solids SB coating[e]	94,784[c]
					High solids SB coating[f]	78,987[c]/49,367[g]
					WB coating[h]	128,086[c]
Large	4,000	6[j]	3[k]	194,370	Baseline coating mix[b]	321,760[c]
					Low solids SB coating[d]	370,275[c]
					Medium solids SB coating[e]	236,976[c]
					High solids SB coating[f]	197,480[c]/123,425[g]
					WB coating[h]	320,238[c]

[a] Does not address EMI/RFI shielding coatings. SB = solventborne. WB = waterborne.

[b] Assumes baseline decorative/exterior coating consumption consists of a mix of coatings as follows:

- 64.8% = Solvent base 2-component catalyzed urethane containing 32 volume % solids at the gun.
- 23.5% = Solvent base two-component catalyzed urethane containing 50 volume % solids at the gun.
- 11.7% = Waterborne acrylic containing 37 volume % solids and 12.6 volume % organic solvent at the gun.

[c] Assumes 25% transfer efficiency (TE) based on the use of air-atomized spray equipment.

[d] Assumes use of a solvent base coating containing 32 volume % solids at the gun.

[e] Assumes use of a solvent base coating containing 50 volume % solids at the gun.

[f] Assumes the use of solvent base 2-component catalyzed urethane coating containing 60 volume % solids at the gun.

[g] Assumes 40% TE based on the use of air-assisted airless spray equipment, as required by new source performance standards.

[h] Assumes the use of a waterborne coating containing 37 volume % solids and 12.6 volume % organic solvent at the gun.

[i] Assumes 2 spray booths are for batch surface coating operations and remaining 3 booths are on a conveyor line.

[j] Assumes 2 spray booths are for batch surface coating operations and remaining 4 booths are on a conveyor line.

[k] Assumes that 3 spray booths are on a conveyor line.

Table 4.2.2.14-3 (Metric Units). REPRESENTATIVE PARAMETERS FOR SURFACE COATING OPERATIONS TO APPLY EMI/RFI SHIELDING COATINGS[a]

Plant Size	Operating Schedule (hr/yr)	Number Of Spray Booths		Surface Area Coated/yr (m^2 Of Plastic)	Coating Option/Control Technique	Coating Sprayed (L/yr)[b]
		Grit Blasting[a]	Zinc Arc Spray[a]			
Small	4,000	0	0	4,921	Low solids SB EMI/RFI shielding coating[c,d]	3,334
					Higher solids SB EMI/RFI shielding coating[d,e]	2,000
					WB EMI/RFI shielding coating[d,f]	1,515
					Zinc arc spray[g-i]	750
Medium	4,000	2	2	109,862	Low solids SB EMI/RFI shielding coating[c,d]	74,414
					Higher solids SB EMI/RFI shielding coating[d,e]	44,648
					WB EMI/RFI shielding coating[d,f]	33,824
					Zinc arc spray[g-i]	16,744
Large	4,000	4	4	239,239	Low solids SB EMI/RFI shielding coating[c,d]	162,040
					Higher solids SB EMI/RFI shielding coating[d,e]	97,224
					WB EMI/RFI shielding coating[d,f]	73,654
					Zinc arc spray[g-i]	34,460

[a] Includes sprayed conductive coatings using the dry filter and water wash spray booths listed in Table 4.2.2.14-2. SB = solventborne. WB = waterborne.
[b] Assumes 50% transfer efficiency (TE).
[c] Assumes use of solvent base EMI/RFI shielding coating containing 15 volume % solids at the gun.
[d] Applied at a 2 mil thickness (standard industry practice).
[e] Assumes use of a solvent base EMI/RFI shielding coating containing 25 volume % solids at the gun.

[f] Assumes use of a waterborne EMI/RFI shielding coating containing 33 volume % solids and 18.8 volume % organic solvent at the gun.
[g] Assumes use of zinc-arc spray shielding.
[h] Applied at a 3 mil thickness (standard industry practice).
[i] Based on amount of zinc wire sprayed per year (kg/yr) and zinc density of 6.32 g/mL.

Table 4.2.2.14-4 (Metric Units). EMISSION FACTORS FOR VOC FROM SURFACE COATING OPERATIONS TO APPLY DECORATIVE/EXTERIOR COATINGS[a,b]

Plant Configuration And Control Technique	kg/m^2 Coated	Volatile Organics	
		kg/yr	kg/hr
Small			
Baseline coating mix[c]	0.84	8,122	2.0
Low solids SB coating[d]	1.14	11,096	2.8
Medium solids SB coating[e]	0.54	5,221	1.3
High solids SB coating[f]	0.36 - 0.22	3,481 - 2,176	0.87 - 0.54
WB coating[g]	0.18	1,778	0.44
Medium			
Baseline coating mix[c]	0.84	64,986	16.2
Low solids SB coating[d]	1.14	88,825	22.2
Medium solids SB coating[e]	0.54	41,800	10.4
High solids SB coating[f]	0.36 - 0.22	27,867 - 17,417	7.0 - 4.4
WB coating[g]	0.18	14,234	3.6
Large			
Baseline coating mix[c]	0.84	162,463	40.6
Low solids SB coating[d]	1.14	222,076	55.5
Medium solids SB coating[e]	0.54	104,506	26.1
High solids SB coating[f]	0.36 - 0.22	69,671 - 43,544	17.4 - 10.9
WB coating[g]	0.18	35,589	8.9

[a] Assumes values given in Table 4.2.2.14-2, using the following equation: E = LDV
where:
E = VOC emission factors from surface coating operations (kg/yr)
L = Volume of coating sprayed (L)
D = Density coating sprayed (kg/L)
V = Volatile content of coating, including dilution solvents added at plant (weight fraction)

[b] Assumes all VOC present is emitted. Values have been rounded off. Does not address EMI/RFI shielding coatings. Assumes annual operating schedule of 4,000 hours. SB = solventborne. WB = waterborne.
[c] Based on use of the baseline coating mix in Table 4.2.2.14-2.
[d] Based on use of a solvent base coating containing 32 volume % solids at the gun.
[e] Based on use of a solvent base coating containing 50 volume % solids at the gun.
[f] Based on use of a solvent base coating containing 60 volume % solids at the gun.
[g] Based on use of a waterborne coating containing 37 volume % solids and 12.6 volume % organic solvent at the gun.

Table 4.2.2.14-5 (Metric Units). EMISSION FACTORS FOR VOC FROM SURFACE COATING OPERATIONS TO APPLY EMI/RFI SHIELDING COATINGS[a,b]

Plant Configuration And Control Technique	kg/m^2 Coated	Volatile Organics	
		kg/yr	kg/hr
Small			
Low solids SB EMI/RFI shielding coating[c]	0.51	2,500	0.62
Higher solids SB EMI/RFI shielding coating[d]	0.27	1,323	0.33
WB EMI/RFI shielding coating[e]	0.05	251	0.063
Zinc-arc spray[f]	0	0	0
Medium			
Low solids SB EMI/RFI shielding coating[c]	0.51	55,787	13.9
Higher solids SB EMI/RFI shielding coating[d]	0.27	29,535	7.4
WB EMI/RFI shielding coating[e]	0.05	5,609	1.4
Zinc-arc spray[f]	0	0	0
Large			
Low solids SB EMI/RFI shielding coating[c]	0.51	121,484	30.4
Higher solids SB EMI/RFI shielding coating[d]	0.27	64,314	16.1
WB EMI/RFI shielding coating[e]	0.05	12,214	3.1
Zinc-arc spray[f]	0	0	0

[a] Assumes values given in Table 4.2.2.14-3, using the following equation: E = LDV
where:
E = VOC emission factors from surface coating operations (kg/yr)
L = Volume of coating sprayed (L)
D = Density coating sprayed (kg/L)
V = Volatile content of coating, including dilution solvents added at plant (fraction by weight)

[b] Assumes all VOC present is emitted. Values have been rounded off. Does not address EMI/RFI shielding coatings. Assumes annual operating schedule of 4,000 hours. SB = solventborne. WB = waterborne.

[c] Assumes use of solvent base EMI/RFI shielding coating containing 15 volume % solids at the gun.

[d] Assumes use of a solvent base EMI/RFI shielding coating containing 25 volume % solids at the gun.

[e] Assumes use of a waterborne EMI/RFI shielding coating containing 33 volume % solids and 18.8 volume % organic solvent at the gun.

[f] Assumes use of a zinc-arc spray shielding.

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1. *Surface Coating Of Plastic Parts For Business Machines—Background Information For Proposed Standards*, EPA-450/3-85-019a, U. S. Environmental Protection Agency, Research Triangle Park, NC, December 1985.

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