Generic Scenario: Electrodeposition
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Process Description

Electrodeposition is the process by which water-borne paints migrate towards and deposit on an electrode of opposite charge. This charge is induced by electric current in solution and determines the type of deposition. Anodic electrodeposition coats a positively charged piece with negatively charged paint particles. Cathodic electrodeposition, which has been more commonly used since the eighties, deposits a positively charged film onto a negatively charged ware. (U.S.EPA, 1994)

Electrodeposition is used primarily by the automobile industry to coat car/truck bodies. Other markets are found in agriculture, for tractors and lawn mowers; in industry for office furniture, electrical switch gear, and wheelbarrows; in the home for furnaces, washers, dryers, and air conditioners; and for smaller metal parts, for example, fasteners, wheels, and seats in the automotive industry. (Electrocoat Technology, 1986)

The process consists of pre-treatment of the article to be painted, painting of the article, and rinsing of the product. (See diagram 1) In order to remove grease from the item, it goes through a series of degreasing and rinsing dips and sprays. It is then immersed, wet, into the dip tank for coating. Dip times range from just seconds to 3 minutes for large pieces. Tanks are usually fully insulated and for cathodic deposition, the negative article is grounded and the positively charged hot electrode paint particles are deposited. (Durney, 1984) The ware is then removed from the bath and rinsed several times to remove excess paint. The rinsate is then returned to the bath in order to conserve undeposited paint. With this returned paint is water in excess of the amount of water loss from the tank. It is therefore necessary to purge the system of excess water. This is frequently accomplished through the use of an ultrafiltration system by which semipermeable membranes selectively allow low molecular weight chemicals such as water to emerge from the system while retaining the paint pigments and additives. Each plant uses a unique rinse process. It is typical, however, to use the filtrate from the ultrafiltration system as one of the rinses. Sometimes it is used for the first rinse after the part leaves the tank and the water and rinsed paint are returned to the tank immediately (Machu, 1978 and Electrocoat, 1994). Other arrangements may allow for the filtrate to run counter-current to the emerging part thus allowing the final rinses to be performed by the most pure filtrate (Durney, 1984). After rinsing, the part is sent to an oven to allow curing of the paint coating. Because some chemical contaminants such as chloride ions, phosphates, chromates and amine solubilizer, build up in the system, the filtrate is periodically purged (Electrodeposition of Coatings, 1973 and Durney, 1984).

The advantages for electrocoating include high corrosion protection, low energy usage, low cost, and low waste. The paint coverage is evenly distributed due to a high throwing power and edges are well protected. Because the paints are recycled in the system, there is very little waste associated with this process. In fact, transfer efficiencies (the ratio of the paint coated to the paint used) range from 95 to 100% (Electrocoat, 1994; Durney, 1984; Brantley, 1989; U.S.EPA, 1978). The disadvantages include large capital investment, an inability to hide defects

in the metal, the ability to use only one paint color per tank at a time, and to use the tank for single coats only. (Durney, 1984)

According to Electrocoat Technology (1986), the approximate composition of paint used for electrodeposition is: 84% deionized water, 0.6% surfactants, 0.3% defoamers, 2.0% crosslinkers, 4% solvents, 2% pigments, 1% grind vehicle, and 6.1% main vehicle. Additives are used for flow control and film building. The solids composition ranges from as low as 5.5% by weight in Industrial Finishing, 1991 to 15% in many of the older sources. Despite the low concentration of solids in the bath, solids (pigment, resins, non-volatiles) make up 95% of the coated material on the product. (Durney, 1984).

Number of Days/year Operation Assume 250

Number of Sites

For new automobile manufacture:

NS = PV/((100,000 kg/site-yr) x (% PMN in paint solids))

Usage/site-yr = 100,000 kg = [(#cars/site-yr)/(surface area of car) x (paint thickness) x (paint density)]/transfer efficiency

Assume # cars/site-yr = 166,000 (basis: U.S.EPA, 1994)
Assume # sites = 61 (basis: U.S.EPA, 3/1994)
Assume surface area of a car: 850 ft^2 (basis: Rodriguez, 1987)
Assume paint thickness is 5^{-5} ft or 0.6 mil (basis: Industrial Finishing, 1991)

Assume density of paint = density of water = 28 kg/ft^3
Assume transfer efficiency of 97% (basis: U.S.EPA, 1988; Electroplate, 1994; Durney, 1984)

For appliance manufacture:

NS = PV/((75,050 kg/site-yr) x (% PMN in paint solids))

Mass used/site-yr = [(surface area coated/hour) x (thickness of coat) x (density of paint) x (16 h/day) x (250 day/yr)]/(transfer efficiency)

Assume 13,000 ft^2/h of laundry cabinets are painted (basis: Production rate of G.E. (Advances...,1971))
Assume coat thickness of 0.6 mil or 5^{-5} ft (basis: Industrial Finishing, 1991)
Assume density = density of water = 28 kg/ft^3
Assume transfer efficiency of 97% (basis: U.S.EPA, 1988; Electroplate, 1994; Durney, 1984)

Environmental Releases

Water:

The frequency of release can range from continuous to every month or less. To express this uncertainty, two methods of calculating releases are presented. In completing the Initial Review Engineering Report (IRER), both release calculations should be presented although an individual use site will likely only discharge on *either* a continuous *or* a periodic basis.

For continuous release of treated ultrafiltrate to onsite WWTP:

Release, kg/site-day = ((0.005) x PV)/[(# sites) x (250 days/yr)] over 250 days/yr
(basis: 0.5% of the paint solids are released to wastewater (U.S.EPA, 1988)

For periodic (monthly) release of treated ultrafiltrate to onsite WWTP:

Release, kg/site-day = ((0.005) x PV)/[(# sites) x (12 days/yr)] over 12 days/yr

Air: Releases are not expected for non-volatile PMN
For vapor pressures greater than 0.001 torr, see CEB models for exposure models.

Landfill/Incineration:

For both new automobile manufacturing and appliance manufacturing, releases will result from filter inefficiencies and container residue:

Releases, kg/yr = 0.065 x (PV)

Release, kg/yr = PV x (1 - transfer efficiency) - water releases + container residues

Assume: 97% of PV is transferred to the article (basis: 97% transfer efficiency (U.S.EPA, 1988; Electroplate, 1994; Durney, 1984)
Assume container residues = 0.04 x PV (basis: liquid container residues are 4% of the production volume (CEB, 1991)

Occupational Exposure

Days/year Potential Exposure: Assume 250

Number of workers/site:

Assume 10 (basis: Average number of Paint shop operators in a single automobile plant was 352 in 1991 and not all of these would be involved in electrodeposition (U.S.EPA, 3/1994)

Inhalation exposure: None is expected for PMN's with low volatility
For vapor pressures greater than 0.001 torr, see CEB model for exposure.

Dermal exposure: To estimate dermal exposure to the PMN during measuring and pouring, the dermal contact model presented in the CEB manual should be used with the following assumptions for incidental 2-hand contact (U.S.EPA, 1991)

$$D = SQC$$

Where:

D = Dermal Exposure (mg/day)
S = Surface area of contact (cm^2) = 1300[a]
Q = Quantity typically remaining on the skin (mg/cm^2) = 1-3
C = Bath Concentration

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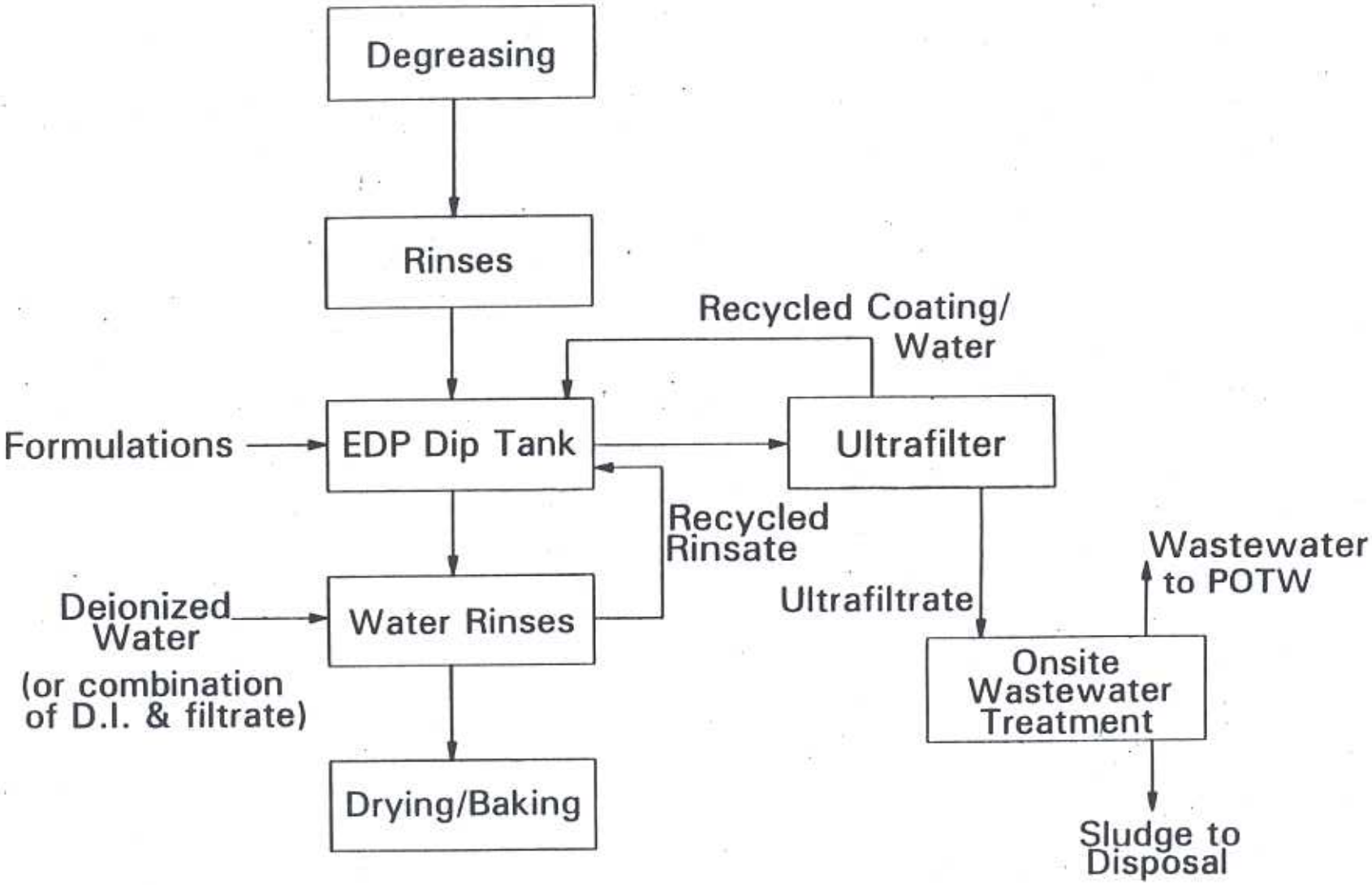

Example Flow Diagram of Electrodeposition of Organic Coatings

Diagram 1