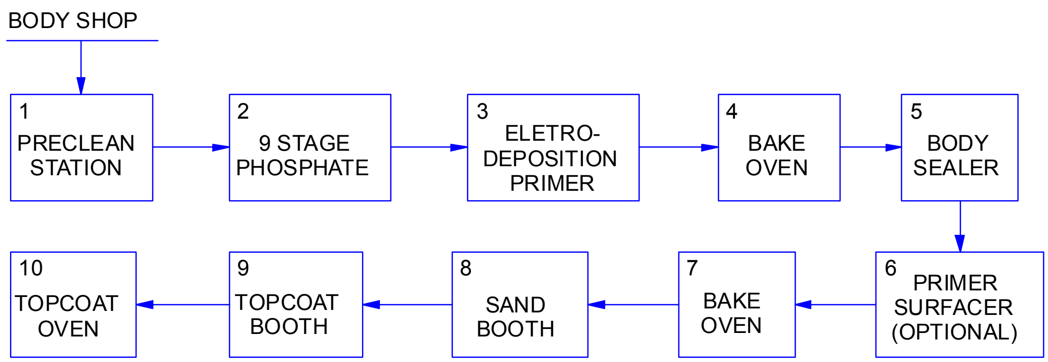
4.5 FINISHING SYSTEMS

The finishing process in a modern assembly plant includes a wide range of operations such as cleaning, pretreating, painting and application of supplemental coatings. These operations are intended to produce a vehicle finish with a high level of customer appeal as well as durability and corrosion resistance. Figure 4.5-1 is a block flow diagram of a typical automotive finishing system. Currently various corrosion resistant coatings are available, such as Zn (zinc) and ZnFe (zinc-iron) which are applied by both the EG (electrogalvanize) and HDG (hot dip galvanize) processes. There may be significant differences in the ways that products respond to finishing processes, depending on the coatings. The designer should be aware of these effects before specifying a material and coating process.



SYSTEM PHASE	BLOCK	APPROXIMATE TIME (MIN)	APPROXIMATE TEMPERATURE ºF
8 Stage Phosphate	2	8 to 16	125 to 140
Electrodeposition Primer Bath	3	2 to 3	80 to 95
Electrodeposition Bake Oven	4	20 to 30	325 to 380*
Primer Surfacer Oven	7	15 to 30	275 to 325
Topcoat Oven	10	15 to 30	250 to 325

*Certain oven zones may have ambient temperatures of 410 ºF; during a line stop, the surface temperature can approach 410 ºF.

Figure 4.5-1 Typical automotive finishing system

4.5.1 PRETREATMENT

Prior to the pretreatment phase, cleaning is done in the body shop to remove sheet metal fines and to prepare the unit for highlighting and inspection. Mill oils, draw compounds, and shop soils such as metal filings are removed in one or more stages of the spray washers. Bodies may be cleaned before or after the installation of doors, deck lids and front end sheet metal. The proprietary cleaners used in the washers are formulated to remove light soils and provide temporary corrosion protection. They must not inhibit or interfere with the subsequent phosphate process. It is therefore important that mill oils and drawing compounds be evaluated for removability as well as lubricating characteristics. Any contaminants remaining on the surface of the unit prior to painting may cause a defect that requires a paint repair.

4.5.1.1 Preclean

A preclean operation is performed, prior to entering the phosphate unit, in which a water based cleaner is applied to the body, either by hand wiping or misting nozzles (Figure 4.5-1 block 1). This phase is intended to soften soils and promote more effective removal during the cleaning stages. Following this step the body enters the first stage of the phosphate unit (block 2).

4.5.1.2 Zinc Phosphate Coating

A high quality zinc phosphate coating is the basis for good paint system performance. Its purpose is to provide a base for paint adhesion and minimize under-film corrosion if the paint film is broken. Each stage may be total spray, total immersion or partial immersion; each is usually one to two minutes in length. A phosphate unit may consist of eight or more stages, which may be all spray, all immersion or a combination. Blocks 1 through 8 in Figure 4.5.1.2-1 show the individual stages in a typical eight-stage zinc phosphate system.

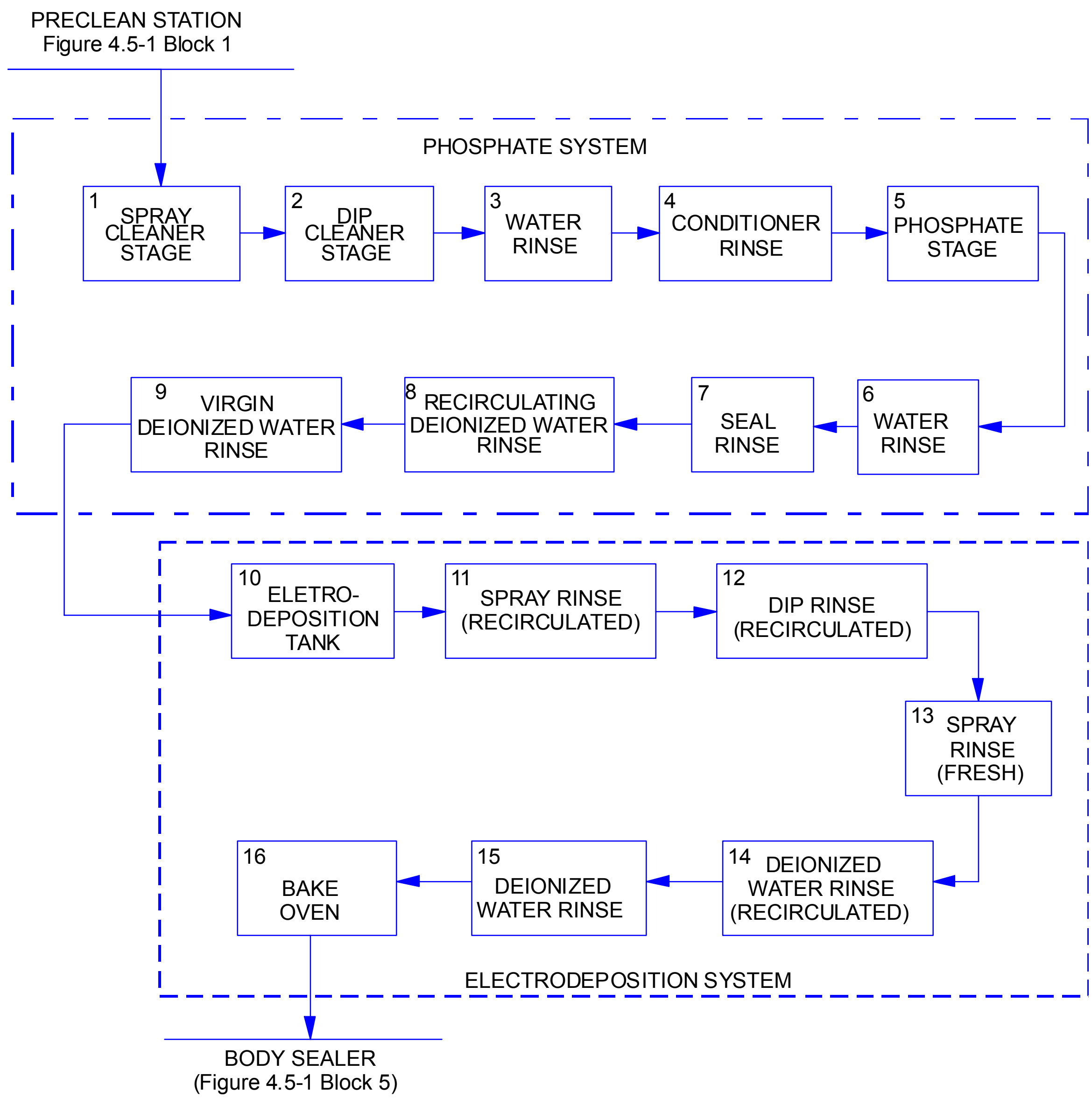


Figure 4.5.1.2-1 Phosphate/electrodeposition system

Spray systems use nozzles to direct the process solutions onto the body. Side, floor and overhead nozzles insure complete coverage of the exterior surfaces of the body. Generally, interior surfaces and box sections are only partially covered by spray or flood nozzles directed through openings in the body. The spray system offers effective cleaning of the exterior surfaces by impingement of the solutions. It offers the advantages of relatively short length of equipment and lower chemical concentrations. The major disadvantages are higher maintenance costs and poor interior coverage. The use of coated steels on interior surfaces can reduce the occurrence of inside-out corrosion, which may result from poor cleaning of interiors.

Immersion systems dip the body into the process solutions. As the body moves through the bath, pumps and piping circulate the solutions, improving coverage on interior sections. In order to obtain maximum effectiveness, interior sections must be designed to allow for the flow of solutions within them. An immersion system offers optimum crystal size, easier chemical control, improved coverage on interior sections and easier maintenance. Disadvantages are greater length of equipment and higher initial cost.

Partial immersion is a combination of spray on the upper portion of the body and immersion on the lower. The compromise between total spray and total immersion is determined by equipment cost, length of equipment, maintenance and effectiveness of the operation.

In a modern nine-stage unit, cleaning and rinsing are accomplished in the first four stages. Two widely used configurations are clean-rinse-clean-rinse (Figure 4.5.1.2-1 blocks 1 through 4) and clean-clean- rinse-rinse. Cleaners used in the phosphate unit must not only clean the metal but also be compatible with the phosphate bath chemistry so as not to inhibit formation of the phosphate coating. For this reason the phosphate system is considered a process and all chemicals are purchased from the same supplier who formulates the bath chemistry to accommodate the processing of various metals.

Immediately before entering the phosphate stage the metal is treated with a proprietary compound to promote a uniform, fine grained phosphate coating (conditioner rinse, block 4). In the phosphate stage (block 5), the coating is formed by spraying or dipping the body in an acidic solution of zinc phosphate, together with other compounds. The crystals are formed on the metal surface through subsequent precipitation of the zinc phosphate. The small grained, tightly compacted uniform coating formed in the process enhances paint adhesion and corrosion resistance. Following the phosphate stage the body is rinsed with water to remove any residual chemicals (block 6).

In the next stage (block 7), the body is rinsed with a material containing chromium compounds to improve the corrosion performance.

The final stage of the phosphate process is a virgin deionized water rinse (block 9) that dilutes any process solutions remaining on the body which, if left on the surface, would reduce durability and cause paint contamination.

4.5.2 ASSEMBLY PLANT PAINT PROCESS

The first step of the paint process in a modern assembly plant is the application of a corrosion resistant primer over the zinc phosphate coating (Figure 4.5-1 block 3). Although some plants still use spray or dip application, most of the automobiles produced worldwide utilize an electrodeposition process. A typical electrodeposition process and subsequent bake operation are amplified in blocks 9 through 15 in Figure 4.5.1.2-1. After application of the primer the coating is cured by a 325-380°F bake, depending on the material, for approximately 20 to 30 minutes (Figure 4.5-1 block 4).

After the application of corrosion resistant primer, the seams, hem flanges and drain holes are sealed with any one of a variety of materials (block 5). Flowable sealers, thumb grade sealers and hot melt patches are usually applied manually, although robot application for flowable sealers is increasing. A short oven bake of 10-15 minutes may be used to set up or gel the sealers. More commonly, the sealers are co-baked with the paint system.

The next step in many processes is the application of a primer-surfacer (block 6), which is formulated to fill minor surface imperfections and supply a base for the color coats. Lately, these primers have been formulated to provide a chip resistant layer to protect the metal from stone damage and corrosion. These can be solvent borne liquid or solvent free powder coatings. The liquid primers can be applied by air or rotary atomized equipment (with or without electrostatics) while the powder coatings require electrostatic rotary atomized equipment. After a bake in the range of 135 to 175°C (275 to 350°F), depending on the material, (block 7) and cool down, the body can be sanded (block 8).

The oven bake cycle is important when bake hardenable steels are used. For a discussion of bake hardenable steels, see Section 2.5.3.

Several methods of sanding may be employed including wet, moist and dry. The total body is usually sanded by the wet process, which utilizes air driven sanders and large quantities of water. Moist sanding involves localized sanding to remove dirt or surface imperfections. Dry sanding may be applied to specific locations or to the total body. As the name implies, it is performed without water. Residual dust must be removed after completion of the sanding operation by water washing, vacuum, air blow off or tack cloth.

The final phase of the painting operation is the application of the color coat (block 9). The majority of the automobiles built worldwide are top coated with enamels. A few lacquer plants remain in operation while awaiting conversion to enamel. High solids enamels and base coat/clear coat are widely used in the United States. However, these are now being replaced by a combination of high solids water borne color base coats and high solids solvent borne clearcoats to meet U.S. Clean Air regulations. A combination of air and rotary atomized equipment is generally used. The topcoat is cured by a 250 to 325°F bake for 15 to 30 minutes, depending on the material (block 10).

4.5.3 PAINT APPLICATION METHODS

A wide variety of paint application methods has been historically used in the automotive industry. The basic categories are dip, flow coat, electrodeposition, air atomized spray and centrifugal atomized spray. Most modern automotive paint lines use a combination of different types of application equipment to obtain the lowest emissions and paint usage with the best finish appearance.

Dip painting is accomplished by immersing the part to be coated in the paint. This method has used both solvent base and water base paints. There are several disadvantages with the process. Paint film thickness is less at the top of the part than the bottom, and the reduced film thickness may cause durability problems. Drips may occur on bottom edges causing both cosmetic and durability problems. Edge coverage is also a problem. Interior areas coated with a dip primer may experience a problem known as solvent wash where trapped solvent vapors wash away the uncured paint.

Flow coat painting utilizes a series of small diameter pipes to flow the paint onto the parts. Interior coverage is usually less than with a dip material, The other disadvantages of the process are the same as with the dip process.

Electrodeposition painting is accomplished by immersing the part to be coated in the paint and applying a charge to the part, which attracts the paint particles. The part may be either positively or negatively charged; most automotive lines today are negatively charged. Process equipment is complex consisting of power supply, pumps, filters, heater, cooler, storage tanks and rinsing equipment.

Major advantages of the electrodeposition process are high transfer efficiency (paint applied versus paint consumed), improved interior section coverage, lower solvent emissions, uniform film thickness and reduced labor. Disadvantages are in the complex and expensive equipment that is required. The process also renders interior coverage highly design dependent. Although the part is completely immersed in the paint, only the areas of the interior sections that receive a current density high enough to cause deposition of the paint are coated. There is a tradeoff between enough holes in an interior section for paint coverage and the adverse effect of the holes on structural and acoustical properties. This, together with the problem of trapped air, presents major design and processing concerns.

The air atomized spray gun is a widely used method for applying primer-surfacers and color coats. This type of gun uses compressed air to break up the liquid paint into finely divided particles, which allows rapid solvent evaporation as the paint is applied to the part. A major disadvantage of this type of process is low transfer efficiency and, in the case of solvent based paints, high solvent emission from the paint booth stacks. Air atomized electrostatic guns use a combination of compressed air at lower pressures and gun tip design to break up the liquid paint before an electrical charge is applied. This method produces more efficient paint usage (greater transfer efficiency). Today's higher solids paints, combined with electrostatic charging of the paint, have improved transfer efficiency and reduced solvent emissions.

The latest development in paint application is the disc or bell. With this method the liquid paint is atomized as it comes off a rapidly rotating (20,000 to 60,000 rpm) disc or bell shaped rotor. An electric charge, typically 80,000 volts, together with low pressure shaping air, directs the paint onto the object to be coated. Transfer efficiency is greater, and solvent emissions are therefore less with this system compared to air atomized application.