

# CADMIUM PLATING

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Most cadmium plating is carried out in alkaline cyanide baths prepared by dissolving cadmium oxide (CdO) in a sodium cyanide (NaCN) solution. Sodium hydroxide (NaOH) and sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) are formed by reactions within and are part of this bath. Cadmium balls suspended in steel wire cages serve as the plating anodes. Typical bath compositions suitable for various plating methods and workpieces are summarized in Table I.

The characteristics of an alkaline cyanide cadmium plating bath are determined by the ratio of the total sodium cyanide to cadmium metal content. Maintenance of the recommended ratio is important to the operating characteristics of the bath. Sodium hydroxide is formed by reaction with CdO and is also added in amounts of about 1.0 oz/gal to improve conductivity of the solutions for barrel plating. It may also be used to counteract solution drag-in. Sodium carbonate is formed by decomposition of NaCN, reaction with carbon dioxide ( $\text{CO}_2$ ) in the air, and by poor anode efficiency.

All of these alkaline cyanide cadmium plating baths employ addition agents to impart a uniform, fine grained deposit. However, excessive amounts of grain refiners are discouraged, and their use is not recommended for cadmium plating on cast iron.

The choice of a plating bath depends on the size and configuration of the workpiece being plated. Large numbers of small parts are most conveniently barrel plated with solutions of a lower NaCN-to-Cd ratio, while larger parts with intricate and recessed surfaces must be coated by still plating techniques of high throwing power. Automatic plating is normally used for intermediate size products which are arranged on racks and then automatically sequenced through a plating procedure.

Other considerations in bath selection include plating efficiency, plating speed, deposit uniformity and hydrogen evolution. For instance, to obtain uniform plate thickness, a current density of 20 to 40 ASF is recommended, but higher values are used for high speed, high efficiency plating. In such a case, however, bath agitation and cooling are required.

Table I. Alkaline Cyanide Cadmium Plating Baths

Total NaCN-to-Cd Ratio.	Concentration, oz/gal				
	Cd	CdO	NaCN	NaOH	$\text{Na}_2\text{CO}_3$
4.0	2.6	3.0	10.4	1.9	4-10
4.1	2.6	3.0	10.7	8.0	4-6
4.5	4.8	5.5	21.6	3.4	4-6
5.0	2.7	3.0	13.5	1.9	4-8
7.2	2.6	3.0	18.2	1.9	4-6

## Preparation of the Plating Bath:

Bath preparation is most conveniently carried out in a spare tank of approximately the same volume as the production plating tank. Fill the tank roughly 70% full of water, heat to 90°F, and dissolve the sodium cyanide. For barrel plating, the 1.0 oz/gal of NaOH should be added at this time. Carefully add the CdO while stirring the solution to insure that the CdO completely dissolves.

After all salts have been dissolved, add 1.5 to 2 lbs of purification grade zinc dust per 100 gallons of solution and stir thoroughly for 30 minutes. Let the solution stand for four hours, then filter it into the production plating tank, leaving about 5% of the solution and sediment at the bottom of the plating bath make-up tank.

Install approximately one cadmium anode per linear foot of conductor bar, and electrolyze at 0.25 to 0.50 V for 24 to 48 hours. Add the grain refiner agent depending on the surface appearance desired, and plate for about two days at a current density of 10 ASF to normalize the solution.

## Operating Conditions:

### *Still Plating:*

A cathode current density of 5 to 70 ASF may be used, but the normal ranges are 15 to 25 ASF for nonagitated baths and 30 to 50 ASF for agitated baths. Either the cathode rod or the solution may be agitated. The maximum anode current density should be about 20 ASF.

When steel wire cages are used to hold the cadmium anode balls, excess anode area must be provided. Up to 50% of the total anode area may consist of case-hardened steel. Bath temperature should be 75 to 90°F, but preferably held at 80 to 85°F.

The cadmium metal content should be held at the desired value between 2.6 and 4.6 oz/gal as determined by the plating process required (e.g., high throwing power or high speed-high efficiency).

The free-cyanide content is normally 8 to 10 oz/gal. At higher temperatures, however, a higher free-cyanide level is necessary to insure uniform results.

The sodium carbonate concentration should be limited to 8 oz/gal or to lower values for high metal content baths, since the presence of both high cadmium metal and high sodium carbonate contents tends to polarize the anodes, limit the usable current density range, and produce dark and streaky deposits.

To obtain the maximum throwing power for still plating, use a bath containing 2.2 oz/gal Cd, total NaCN of 17 oz/gal (Cd-to-NaCN ratio of 7.7), and operated at 10 ASF.

### *Barrel Plating:*

Small barrels may be operated at 6 to 8V. For barrels larger than 14" diameter by 30" long, the voltage must be 10 to 12V. The other operating conditions are similar to those for still plating.

Small lightweight parts are normally plated by barrel plating at low current densities (5 to 7 ASF) depending on the metal concentration and bath temperature. Under these conditions, 0.2 mil of cadmium will be barrel plated in 20 to 30 minutes.

## Brighteners:

Organic or metallic compounds are often added to alkaline cyanide cadmium plating baths to influence the formation of the electrodeposited cadmium crystals and thus the brightness of the coating. They are largely proprietary and, among the organics, include:

Aldehydes	Furfural	Molasses
Coumarin	Gelatin	Sugar
Dextrin	Milk	Some Sulfonic Acids

Metallic brighteners include nickel, cobalt, molybdenum and selenium compounds.

Best results are achieved by a moderate use of both types. Excessive amounts of the organic brighteners are less harmful in that they ultimately hydrolyze and become harmless. Metallic brighteners should never be used unless technical facilities and competent personnel are available. Baths which are used excessively and which contain large amounts of organic brighteners must be filtered frequently or continuously.

## NON-CYANIDE PLATING BATHS

In recent years, the need for pollution control of cyanide solutions and for cadmium plating solutions which generate minimal hydrogen evolution has led to development of several non-cyanide cadmium plating baths. These solutions are a neutral sulfate, an acid fluoborate, or an acid sulfate.

The compositions and operating conditions of each of these baths, along with those of one of the typical alkaline cyanide solutions, are summarized in Table II. Brighteners are generally added to these baths as required, and the cadmium anodes are normally of 99.95% purity.

Of the four plating baths outlined in Table II, the acid fluoborate bath is capable of high cathode efficiency at high current density but does not, along with the other non-cyanide baths, have the excellent throwing power of the alkaline cyanide bath. Because of their higher cathode efficiency, the non-cyanide baths are often preferred for the cadmium plating of quenched and tempered high strength steels since less hydrogen is generated at the cathode, and any danger of hydrogen embrittlement is much less.

In any case, all cadmium plated high strength parts are usually based at 375°F with in four hours of plating to drive off any hydrogen present. The baking times vary from 30 minutes to 23 hours, depending on the specification, and are a function of both the base steel strength level and the maximum section thickness of the plated part.

Table II. Typical Cadmium Electroplating Baths

<i>Bath Component (oz/gal) or Operating Condition</i>	<i>Alkaline Cyanide</i>	<i>Neutral Sulfate</i>	<i>Acid Fluoborate</i>	<i>Acid Sulfate</i>
Ammonium chloride	—	1.5-3.0	—	—
Ammonium fluoborate	—	—	8.0	—
Ammonium sulfate	—	10.0-15.0	—	—
Boric acid	—	—	3.6	—
Cadmium	2.7	0.5-1.5	12.6	—
Cadmium fluoborate	—	—	32.2	—
Cadmium oxide	3.0	—	—	1.0-1.5
Sodium carbonate	4.0-8.0	—	—	—
Sodium cyanide	13.5	—	—	—
Sodium hydroxide	1.9	—	—	—
Sulfuric acid	—	—	—	4.5-5.0
Current density, ASF	5-90	2-15	30-60	10-60
Temperature, °F	60-100	60-100	70-100	60-90