WATER IN ELECTROPLATING INDUSTRY

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ABSTRACT

Water for electroplating is as important as any of the chemicals used in the process. Water is used in processing and in rinsing. It is essential that proper quality of water is used to achieve the desired effect. As our country gets more and more industrialised, the consumption of water will increase. Judicious use of water is essential. Apart from the use of water, the treatment of waste water is posing a great problem.

INTRODUCTION

1. 1 The global importance of water to electroplaters has been emphasised in a report to the International Union of Pure and Applied Chemistry (IUPAC) on the world survey covering the economic use of water and the effluent problem of the electroplating industry. The problem is universal, of course, because of the large amount of rinse water considered necessary by the electroplating fraternity generally. The character of the rinse water discharged into the rivers or sewer systems may be related to each other, but the character of water received by the different plating establishments cannot be the same. The two prime water problems of the plating industry supply and effluent vary in magnitude depending on the industrialisation of each country.(1)

1. 2 In India water is drawn from rivers, tanks, lakes, open wells and bore wells. The raw water varies in characteristics widely. Some types of water are unsuitable for electroplating industry and very little information is available regarding the unsuitability of water obtaining in our country for plating industry. The importance of water in the plating shop is frequently disregarded or minimised. More importance to quality and quantity of water would be given if it were realised that water is by far the largest tonnage of material used in plating operations.

2. INDUSTRIAL USE OF WATER

2. 1 Man's industrial progress can be traced by studying his utilisation and exploitation of the earth's water courses. Our future industrial progress will, in a large measure, be determined by our rational use of water. Industrial operations entail a demand for water both in quantity and quality. These two requirements vary not only between different types of plants but also for different uses within each plant. A secure water supply must be a basic consideration in the selection of a site for any industrial plant. Many industrial uses are made of water in a modern plant and frequently there are differences in the characteristics of the waters required (2).

2. 2 **Industrial Uses of Water** — Industrial uses of water may be grouped in seven basic categories (i.e.,) steam generation, heat transfer, solvent action, carrier, raw material, kinetic energy, and nuclear energy. Every plant will not necessarily use water in all seven ways; water use varies widely among different types of industry. These individual uses and variations in emphasis on common uses make the problem of water supply peculiar to each industry.

Water is used in the chemical industry in every known way. Large volumes of water are employed for condensing and cooling, as a reactant, as an universal solvent and in the form of steam. The principal use of water in steel mills is for cooling, in pickling, for washing, etc. Quality of the process water is important in the food and beverages industries. The importance of water for the paper industry can be judged by the fact that it has set standards for making each grade of paper. In the leather industry water is used for soaking before removing hair and blobular proteins, washing and for tanning. Water of excellent quality is necessary for textile manufacturing and in many mills the quality of water used meets the standards of potable water or exceeds them. Hydraulic mining of ores and minerals uses great volumes of water to flush the desired material from its natural location in the earth. The coal mining industry uses a large volume of water for washing the product to prepare

a clean burning fuel. The industrial uses of water are legion and the demands on water vary over wide limits, each industry has its individual problems (2).

3. REQUIREMENTS FOR ELECTROPLATING INDUSTRY

3. 1 Recently water has begun to get the attention it deserves, because of the growing realisation that the supply of good quality of water with which nature has provided us is limited and in some locations the demand equals or surpasses the supply. The result has been that often the location of new plants has hinged largely upon the availability of water and sometimes complex water treatment — has been necessary to make the available water satisfactory for plating purposes. Greater attention is constantly being paid to improving the quality of plated work and in many cases the quality of water used is of primary importance in achieving satisfactory finished work. For decorative plating water spots and stains may necessitate reworking, wiping, buffing or other labour consuming operations (3).

3. 2 A very wide variety of the individual components normally present in water have been known to cause difficulties in various plating operations. In Table I, some of the effects of impurities of water in electroplating baths are given.

3. 3 **Types of Impurities in Water** — The types of impurities in water can be groupedyoi gether as cations, anions, turbidity, dissolved gasses and micro organisms (3). Among the cations are grouped hardness, alkali metals, heavy metals and acidity. The most objectionable of these is hardness, consisting of calcium and magnesium ions. These ions are undesirable because of the rather limited solubility of the compounds with which they are generally combined in waters. The solubility of calcium salts will decrease upon heating and with consequent evaporation they may concentrate and cause a sludge in the water. In general, calcium is present in waters to approximately twice the extent of the magnesium. The hardness of usable water ranges from 10 to 500 ppm. For plating purposes calcium and magnesium hardness has to be removed. The alkali metals, sodium and potasium are not generally harmful in plating operations. But in nickel plating solution substantial amount of these may cause brittleness of the plate and/or lower the maximum allowable current density. Again in final rinse water solid content is undesirable for plating. Acidic water is unsuitable for plating. The cations mentioned earlier are normally present in water as salts combined with the following anions in the order of their relative average abundance in varlous water supplies: (a) bicarbonates, (b) sulphates, (c) chlorides and (d) nitrates. Bicarbonates, nitra-

TABLE I: *Effect of some water impurities in electroplating baths*

Bath	*Calcium*	*Magnesium*	*Sodium*	*Iron*	*Bi-carbonate*	*Chloride*	*Organic*
Cadmium Cyanide	1	1	—	4	—	—	—
,, fluoborate						2	8,9
Chromium	—	5	5	5	—	—	7
Acid Copper	—	—	—	2	—	6	—
Cyanide Cu	1	1		1	—	—	10
Cu. fluoborate	—	—	—	—	—	2	—
Ni. sulphate	1		11	2,8,10,11	11		4,8,10
Silver cyanide	1	1	—	12	—	13	2,8
Alkaline tin	1	1	—	—	—	—	—
Acid tin	—	—	—	—	—	14	—
Zinc cyanide	1,2	1	—	—	—	—	—
Zinc sulphate	—	—	—	15	—	—	—

1. Precipitate in bath
2. Roughness of deposits
3. Porosity of deposits
4. Hazy deposits
5. Reduced throwing power
6. Nodular deposits
7. Reduces Cr
8. Streakiness of deposits
9. Bad colour deposits
10. Pitting of deposits
11. Brittle deposits
12. Staining of ,,
13. Iridescent ,,
14. Crystalline ,,
15. Lowerplating efficiency.

TABLE II: *Quality of Water for the Electroplating* (5)

	Good	*Bad*
pH	7.6-7.9	
Total Solid Matter	5	20
Albumenoid Ammonia	.005	.1
Chlorides	1	
Nitrates	.05	.1
Hardness Temporary	0	10
,, Permanent	2	6

Note : The results are expressed in parts per hundred thousand.

tes, silicates, chlorides and sulphates may be objectionable in plating operations. Turbidity is the term applied to suspended matter of any nature present in water supply. Turbidity is objectionable for all practical uses and for most purposes should not exceed 10 ppm. In addition to the suspended material and dissolved salts, gases are frequently found in water. Carbon dioxide is corrosive of itself, as in solution forms carbonic acid which lowers the pH and this lowered pH accelerates dissolved oxygen corrosion. The solubility of oxygen decreases with increase in temperature of the water. Oxygen being an active element is corrosive to steel and tin and this corrosive property increases with increase in temperature and is maximum in the temperature of 160° — 180°F. Apart from their corrosive properties carbon dioxide and oxygen present in water have very little effect in plating operation. Nitrogen being inert causes very little difficulties.

3. 4 **Methods of Treatment**—No elaborate treatment for the removal of the impurities in water is attempted here. Some of the important processes are indicated. Pressure filtration is used to remove suspended impurities from water. Precipitation is a process commonly used to remove hardness, turbidity, colour, odour, alkalinity, silica and fluorides. Though the impurities cannot be removed completely, it is a very economical process. Sequestration of chelating agents maintain the undesirable metals in solution and thus prevent them from depositing on to the cathode. Ion exchange is a very popular method and ion exchangers are a commonly insoluble granular materials which have the property of exchanging ions in their structure for ions in the water. The ion exchangers are organic materials. For most plating operations the use of a weak basic anion exchanger which will remove sulphates and chlorides but allow the carbonic acid to remain is completely satisfactory. Silica and carbon dioxide can be removed by highly basic anion exchange resin but silica removal is not of great impurtance for plating operations. The following table gives the limits of impurities in water that can be tolerated for plating purposes.

3. 5 **Typical Water Analysis** — Before embarking on the process of plating the quality of water available to industry has to be assessed. In large industries water treatment is provided by themselves. But many industries purchase municipal water for drinking and cooking purposes and rely on their own for the other purposes. Thus the water to be treated will vary widely in quality and it is difficult to treat such a composite type of water. The following table gives a comparative idea of the quality of the water from different sources.

4. ECONOMIC USE OF WATER

4. 1 Water is used in the electroplating industry for bath make-up replacement of evaporation losses in baths, rinse water, cooling water and in boilers. Water for bath makeup and replacement of evaporation losses can be easily estimated, the latter being negligible. Generally the drag out rinses are used to top up. The quantity of water used for cooling is not also considerable. The water used in boiler depends on the number of vats and rinses require to be heated. The quantity of water can easily be estimated. By far the largest consumption of water is for rinses. Estimation of rinse water demand is rather difficult and should be based on experience with the type of work being treated. In arriving at the volume of water required for rinses there are a number of factors to be considered; chief of them being the concentration of the bath, the method of jigging/rack-

TABLE III: *Analysis of Water from Deep Bore Well* *

S. No.	*Constituents*	*Parts per Million*
1.	Total solids	290.0
2.	Organic matter	55.0
3.	Inorganic matter	235.0
4.	Sulphate (as So4)	10.1
5.	Chloride (as Cl)	33.0
6.	Total Silica (as Sio2)	58.2
7.	Dissloved silica (as Sio2)	48.8
8.	Iron and Aluminium ($Fe_2 0_3 — Al_2 0_3$)	10.5
9.	Calcium (as Ca Co3)	45.5
10.	Magnesium (as Mg Co3)	17.0
11.	Alkali Metals (as Na 2 O)	100.0
12.	'Alkalinity' (Bicarbonates) (as Ca Co3)	136.0
13.	Permanent Hardness (as Ca Co3)	90.0
14.	pH (electrometric)	7.85

*(Analytical figures provided by the courtesy of M/s. Indian Telephone Industries Ltd., Bangalore.)

TABLE IV: *Analysis of Water (Bore Well plus Municipal Water Supply)* *

S. No.	*Constituents*	*Parts per Million*
1.	Suspended imputities	fairly clear
2.	Total dissolved solids	245
3.	Total hardness of water (Ca Mg Hardness) as Ca Co3	42.48 ppm.
4.	Temporary or carbonate hardness	25 ppm as Ca Co3
5.	Permanent or non-carbonate hardness	80 ppm as Ca Co3
6.	Alkalinity to phenolphthalein	Neutral
7.	Alkalinity to methly orange	26 ppm as Ca Co3
8.	Total chlorides as Cl	12.86 ppm
9.	Total sulphate as S04	23.48 ppm.
10.	Total iron content	7 ppm as Fe
11.	Total silica content	47.84 ppm as Si O2
12.	pH value of the water	7.85 at 26 C

*Analytical figures provided by the courtesy of M/s Indian Telephone Industries Ltd., Bangalore-16.

ing, whether vertical or horizontal, rinsing, the shape of the component or article, the number of recesses or pockets, mode of operation of plating, automatic or manual, and the time allowed for rinsing. Rate of flow of rinse water also decides the volume of water used for such purposes. The proper design of rinse tanks, introduction of dragout tanks, multiple series rinses, wherever possible, reduce the water consumption considerably. Counter-current and spray mixing also help in reducing water consumption. The importance of drag-out volume of solution per unit area of a flat surface is given by Soderberg (7) in Table V.

TABLE V: *Drag out per Unit area*

S. No.	*Description*	*Drag-out gal/ 1000 sq. ft.*
1.	Vertical parts, well drained	0.4*
2.	Vertical parts, poorly drained	2.0
3.	Vertical parts very poorly drained	4.0
4.	Horizontal parts, well drained	0.8
5.	Horizontal parts very poorly drained	10.0
6.	Cup-shaped parts, very poorly drained	8.0 to 24.0 or more

*This figure may be taken as the absolute minimum for dragout on a vertical sheet.

The table is useful in running calculations and in estimating expected solution losses and the corresponding load on waste treatment process.

4. 2 Careful planning is essential to make available to the plating industry adequate and economic water supply. Preparation of a plant water balance is the logical way to accomplish this. Flow diagram for the entire water requirement has to be prepared first. Next the quality of water required for each phase of the process has to be formulated. Survey of the quantity and quality of water available has to be made. Based on these factors the purification or treatment equipment has to be designed. Reuse of water for certain processes will greatly reduce the consumption of water. A well prepared and up-to-date water plan will enable to overcome any sudden bottleneck or lack of water supply for the various processes.

5. DISPOSAL OF PLATING WASTE:

5.1 Waste water has to be run into streams, thanks or sewers Treatment of plating room waste is assuming importance as the waste water contains toxic and corrosive material to sewers and harmful to the biological processes in the sewage disposal plant. Pollution affects streams and sewers and this may have injurious effect on public health, and safety on acquatic

TABLE VI: *Analysis of Dilute Plating Effluent before and after Treatment**

S. No.	*Description*	*After Treatment*	*Before Treatment*
1.	pH	9-9.5	1.3-2.2
2.	Total Acidity	-	1000-2000 ppm
3.	Mineral Acidity	-	900-1400 ,,
4.	Sulphate	1129 ppm	1470-2000 ,,
5.	Total Dissolved Solids	1484 ,,	850-1600 ,,
6.	Suspended Solids	-	nil
7.	Nickel	nil	8- 30 ,,
8.	Copper	1.2	25-100 ,,
9.	Iron Oxide	Nil (Colorimetric)	60-100 ,,
10.	Silicon	-	14- 40 ,,
11.	Chloride	Nil	200-400 ,,
12.	Cyanide	Nil	nil
13.	Chromate	Nil	nil- 40 ,,

*(Analysis of plating waste before and after treatment provided by the courtesy of M/s Indian Telephone Industries Ltd., Bangalore).

TABLE VII: *Range of permissible concentration of Constituents in Effluent USA* (4)

Constituent	*Effluent to streams*	*Range of permissible Concn ppm In streams*	*Influent to sewer*
Fe	5	2-10	5
CN	"None" to 0.5	"None" to 0.2	2
Ferro cyanide) Ferri cyanide)	-	0.4	-
Cu	-	0.4	1 to 3
Zn	-	0.3 to 15	-
Cd	-	0.3	-
Ni	-	-	1 - 3
Pb	1-3	0.5 to 2	3 - 5
Cr^6	-	0.35	0.1
Cl_2 residual	0.5 - 1.5	-	-
NH_3 or NH_4	-	2	-
Free acid, as H2 SO4	-	20	None
Oil	-		-
Alkalies, as Na OH	-	-	-
pH	6.5-9.5	6.3-9	5-6 .5

and other life, deterioration of property and intangible losses. Pollution is due to toxic substances like acids, alkalies, cynides, chromates and heavy metal salts from the rinse water. The following table gives a typical dilute plating rinse waste in India.

The electroplating industry like many other wet process industries has to use a considerable quantity of water but no part of water is sold in the final product. All the water consumed by the plating establishment must be disposed of as waste.

5. 2 The methods of treating different wastes can form the subject matter of a separate paper and no attempt has been made to describe them here. The treatment depends on the final contamination permitted in the rinse water and the economics of the process. If some portion of the effluent can be used after treatment, the method of treatment has to be adapted suitably. Reuse of waste water has to be reckoned with the cost of treatment and if the cost of treatment outweights the cost of water, there is no use in attempting to treat the water, except, of course, to reduce the toxicity to the permissible limits. The limits of permissible impurities in various countries are given in the following Tables:

TABLE VIII: *German Effluent Limits* (8)
(Effluent water from Electroplating Shops Basic Maxima)

pH	6.5 — 9.0
Chromium	2 ppm
Zinc	2 ppm
Cadmium	2 ppm
Iron	2 ppm
Copper	1 ppm
Nickel	1 ppm
Cyanide free	0.1 ppm
Chlorine	0.5 ppm
Solids	0.3 cc/l

TABLE IX: *Suggested (Max) Principal Contaminants for discharge to a stream or sewer (UK)* (6)

Substance	*Stream parts per million*	*Sewer parts per million*
Sodium cyanide	0.1	4
Chromic as chromic acid	2.0	5
Copper	1	3
Iron	—	5
pH	5-8	Over 5

From the foregoing, it may be seen that the disposal of plating room waste presents a difficult problem and has to be decided depending on the local conditions.

6. CONCLUSION

6. 1 Next to the deposition plant, probably one of the most important items to be considered in layout of a plating shop is the supply and use of water and the provision of satisfactory drainage. Water is used in the plating shop in plating processes and for swilling. For both the purposes the composition of the water is of great importance. The importance of the quality of water is remembered when plating solutions are being made, it is too often forgotten when articles are being swilled. The economic use of water is equally important. The discharge of effluent from plating shop is assuming greater importance and it is essential that the contaminants in the final effluent are brought down to the lowest concentration.

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